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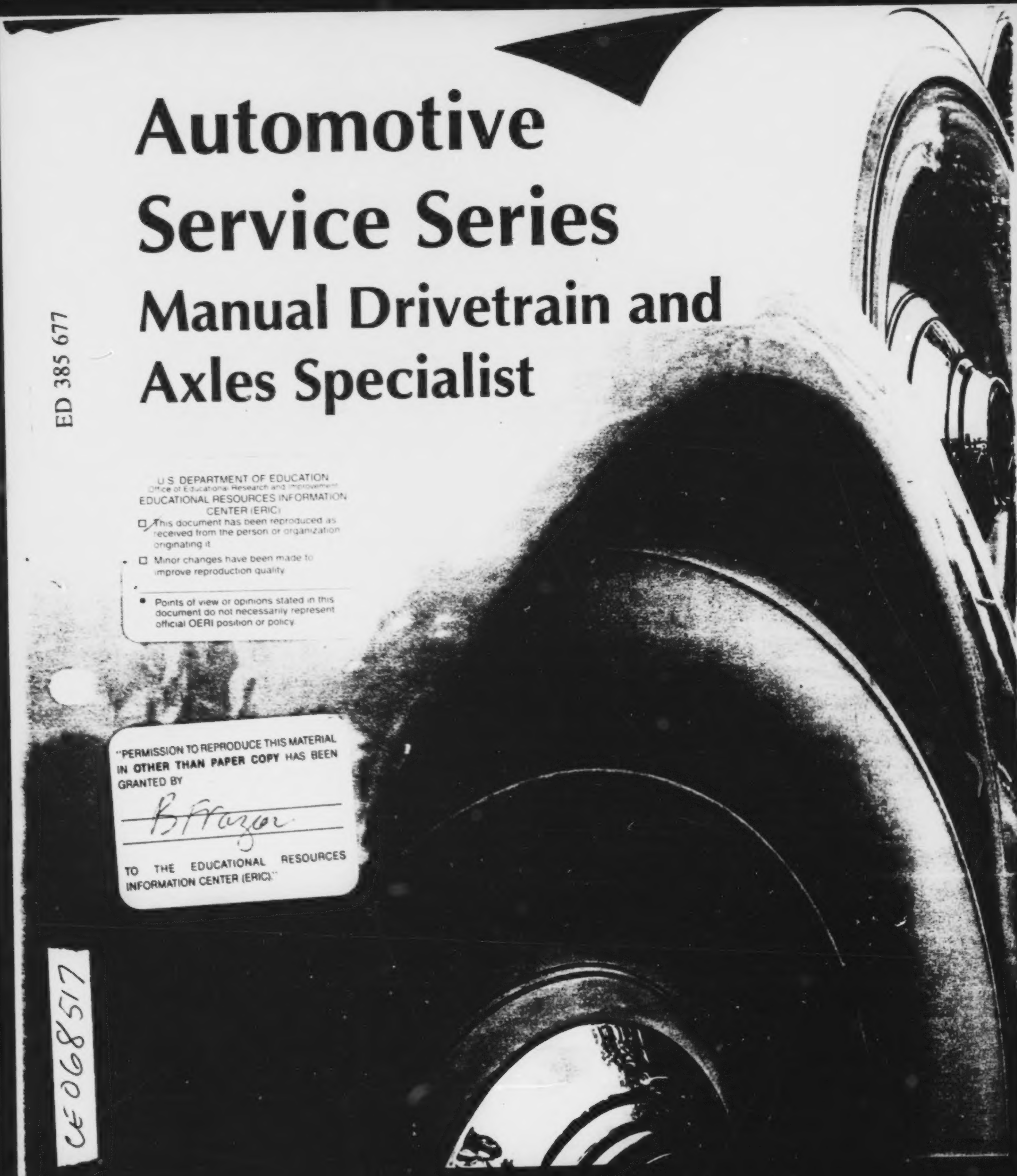
ABSTRACT

This instructor's guide contains materials for teaching the manual drive trains and axle specialist component of a competency-based instructional program for students preparing for employment in the automotive service trade. It is based on National Institute of Automotive Service Excellence task lists. Six instructional units contain materials designed to teach students to service the following: drivelines, differentials and rear drive axles, clutches, manual transmissions, manual transaxles and front drive axles, and four-wheel drives. Each unit includes the following: performance objectives, suggested activities, pretests, information sheets, assignment sheets, job sheets and their practical tests, written tests, and answers to all tests and assignments. Some units also include handouts, supplements, transparency masters, and activity sheets. Transparency masters, handouts, pretests, practical tests, and written tests are included in the instructor edition only. All unit components focus on measurable and observable learning outcomes, and all units incorporate activities to help students master basic skills required for the workplace. In addition, each unit includes information on the following: using the materials for independent study, amounts of material to cover in single class periods, skills that must be demonstrated, supplies/equipment needed, amounts of class time required for demonstrations and student practice, supplementary materials to order, and resource people to contact. A basic skills matrix correlates competencies and skills. (MN)



Automotive Service Series

Manual Drivetrain and Axles Specialist

ED 385 677

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Teacher Edition

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Oklahoma Department of
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1500 West Seventh Avenue
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Manual Drivetrain and Axles Specialist

Developed by the
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for the Division of Trade and Industrial Education
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Manual Drivetrain and Axles Specialist

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FOREWORD

This is one in a series of eight automotive service specialty publications that is based on the National Institute of Automotive Service Excellence (ASE) task lists. This series provides instruction for all high-priority competencies established by ASE and will contribute greatly to an auto service technology program's ability to meet the requirements of a nationally certified training school.

The ASE competencies are developed by industry to meet the industry's need for quality technicians. This curriculum addresses that need. The industry and education committee that has validated the technical accuracy of this material is commended for outstanding service and commitment to the quality of these instructional units. The instructors and students who use this material are challenged to have the same commitment to excellence.

We trust that this instructional material will meet students' needs as they prepare for careers in manual drivetrain and axles service.

Dr. Roy Peters, Jr., State Director
Oklahoma Department of
Vocational and Technical Education

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Only with the close cooperation of the Curriculum and Instructional Materials Center staff was this curriculum developed. Sincere thanks are shared with the current as well as former CIMC coordinators.

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Special appreciation is offered to the other individuals on the CIMC staff who functioned in important supportive roles throughout the development of the *Manual Drivetrain and Axles Specialist* curriculum: Sherry Wietelman, curriculum specialist, who chaired the validation committee meeting; Terri Tomson, secretary, who provided a great deal of assistance, including the organization of the massive tracking of permission letters for the illustrations; Carl Rose and Camille Baker, who proofread the final copy; and Tom Fields, audio visual production specialist, for the excellent photographs. Thanks also to the many other members of the CIMC staff who so generously provided the support, help, and advice that was needed for this project.

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And finally, a very special acknowledgment goes to Chuck Pendergast, the technical advisor for this project, without whose expert collaboration, advice, support, review, and encouragement this curriculum would not have been possible.

Lynnette Johnson
Technical Writer
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PREFACE

The purpose of *Manual Drivetrain and Axles Specialist* is to continue the students' training in the automotive service trade by providing instruction in this specialty area. This publication is one in a series of eight publications for automotive specialty areas. Other areas included in this series are brakes, steering and suspension, engine repair, engine performance, electrical, heating and air conditioning, and automatic transmission/transaxle.

Instructors are faced with the challenge of teaching the skills and related information necessary for their students to become the highly-qualified automotive service specialists that are in demand today. This curriculum is designed to help instructors meet this challenge. The objectives in this curriculum are based on those National Institute of Automotive Service Excellence (ASE) tasks that are required of an automotive manual drivetrain and axles technician.

Lynnette Johnson
Technical Writer
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Technical Education

USE OF THIS PUBLICATION

INSTRUCTIONAL UNITS

Manual Drivetrain and Axles Specialist contains six units. Each instructional unit includes basic components that form a unit of instruction: performance objectives, suggested activities, pretests and pretest answers, information sheets, assignment sheets and assignment sheet answers, job sheets and their practical tests, and written tests and written test answers. Handouts, supplements, transparency masters, and activity sheets are optional components which may be included in some or all of the units. Transparency masters, handouts, pretests, practical tests, and written tests are included in the instructor edition only and may be duplicated for classroom use. Test packets may be purchased in Oklahoma by calling 1-800-522-5810. Out-of-state instructors may order test packets by calling 1-800 654-4502.

The unit components focus on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. By carefully studying each unit of instruction, the instructor will be able to plan presentations and demonstrations to meet the needs of the students as well as determine the following:

- How to use the materials for independent study
- Amount of material to cover in a single class period
- Skills that must be demonstrated
- Supplies and equipment needed
- Amount of class time required for demonstrations
- Amount of class time required for student practice
- Supplementary materials to order, such as pamphlets, videos, or software
- Resource people to contact

Objective Sheets (White Pages)

Each unit of instruction is based on the knowledge and skills needed for successful employment in an occupational area. What the student must know and be able to do has been translated into performance objectives which are stated in two forms. ***Unit objectives*** state the subject matter to be covered in a unit of instruction, what the student should be able to do and what standard will be used to determine whether the student has achieved competency. ***Specific objectives*** outline the teaching sequence and state the performance necessary to meet the unit objective.

The objectives can also help determine teaching strategies and instructional methods. Instructors will need to decide how each objective can best be taught (individualized or class instruction) to their students prior to beginning the unit. Instructors should feel free to modify, delete, or add objectives in order to meet the needs of the students and the community. If objectives are added, the instructor should remember to supply the needed information, assignment sheets, job sheets, practical tests, and criterion test items.

Suggested Activities (Pink Pages) — **Instructor's Edition Only**

This component assists the instructor during the preparation stage of the teaching/learning process by providing suggestions for delivery, enrichment, and application during the instructional process. Teaching suggestions are included for each objective. The instructor should read the suggested activities before teaching the units to allow time to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the instructor will vary according to the particular unit.

Included in this component are suggested resources of books, audiovisual materials, and software which may be used to teach the unit. References used in the development of each unit are also provided. Instructors can use suggested resources and unit references to supplement their knowledge of the subject or to help students with particular interests or occupational objectives in the subject area.

Handouts (White Pages) — **Instructor's Edition Only**

Handouts are additional teaching aids that support portions of the information sheet by providing "nice-to-know" information which is not testable. They may include activities such as games, puzzles or supplementary information on subjects that are considered to be controversial. The instructor may decide whether to duplicate and use handouts in teaching the unit.

Pretests (Yellow Pages) — **Instructor's Edition Only**

Because students bring a variety of background experiences and knowledge to the classroom, pretests are included to allow the student the opportunity to demonstrate previously gained information. The pretest provides a criterion-referenced tool for evaluating students' knowledge prior to studying the unit. For a description of this component, please refer to the written test description.

Pretest Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on the pretest.

Information Sheets (Green Pages)

The information sheets provide "must know" content that is essential for meeting the cognitive objectives. The information sheets serve as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit. Program coordinators, directors, and/or instructors are encouraged to select and acquire textbooks for students in order to supplement and expand the material covered in the information sheets.

The information sheets may include notes, cautions, or warnings. These should be discussed carefully and thoroughly. ***Notes*** are short verbal additions to the information that provide nice-to-know and decision-making information. A note may tell the student what to look for or consider at a given step or may explain when a step may not be applicable. Notes offer guidance that may help the student understand the process and accomplish it more efficiently. ***Cautions*** are advisories that alert students to conditions or situations which may result in physical damage to themselves, the vehicle, or equipment. ***Warnings*** are advisories that alert the student to dangers which may result in critical or fatal damage to themselves or major damage to the vehicle or equipment.

Supplements (Green Pages)

Supplements include material that provides additional information for understanding the topic but may not have direct application to specific objectives. Instructions that might be used for solving problems, tables, charts, written information, forms, or other information students might need in order to complete one or more of the assignment or job sheets could be included as a supplement. While information in supplements is not tested directly, it may be used to assist the student in meeting the performance objectives.

Transparency Masters (White Pages) — **Instructor's Edition Only**

Transparency masters provide information in a special way. They direct the class's attention to the topic of discussion and allow the instructor to illustrate the topic. The use of transparencies is especially effective for visual learners who prefer to see the topic being presented as well as hear about it. Transparencies may present new information or they may reinforce information presented in the information sheets. Transparencies should be made ahead of time and placed with the rest of the materials necessary to teach the unit.

Activity Sheets (Tan Pages)

Activity sheets provide activities which support several objectives or deal with students' attitudes, beliefs or appreciation of the study area. Some may ask rather personal questions and are only intended for each student's personal use while other activity sheets may require the student to monitor his or her own actions or other personal variables over a period of time. Activity sheets will vary greatly in their design from unit to unit. When Activity Sheet Answers (pink pages) are provided, they are found only in the Teacher's Edition.

Assignment Sheets (Tan Pages)

Assignment sheets provide written exercises for instruction and practice of a specific objective. The introduction to the assignment sheet explains how the assignment sheet relates to the subject area and unit objectives and may provide instructional information or refer students to another component for such information.

Assignment sheets are intended to provide students with practice in exercising higher-order thinking skills. Often assignment sheets will contain case studies, story problems, or other situations in which the student must analyze the circumstances and determine correct responses. Students may be given assignment sheets in class or as homework.

Assignment Sheet Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on assignment sheets.

Job Sheets (Blue Pages)

Job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure to complete each task or job. Diagrams, photographs, and illustrations may be included to assist students in achieving the skill.

The instructor should demonstrate the procedures outlined in each job sheet. Furthermore, the instructor needs to localize the procedure according to the equipment and supplies available in the local lab situation. Job sheets also show potential employers what skills the students are learning and the performances they might reasonably expect from students who have had this vocational instruction.

Practical Tests (Yellow Pages) — **Instructor's Edition Only**

Practical tests assist the instructor in evaluating the psychomotor activities (job sheets). The practical tests provide instructors with a valid mechanism for determining a student's level of ability to perform the procedure stated on the job sheet and a means of evaluating the student's final product.

Written Tests (Yellow Pages) — **Instructor's Edition Only**

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. All performance objectives will be evaluated. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test.

The tests may be written or oral. It may be advisable to divide the tests into shorter tests covering three or four objectives at a time and give them soon after those objectives are covered.

The acceptable response on a written test, eighty-five (85) percent in most units, applies to the overall score, not to each individual question. The final unit grade should be obtained by combining written test and assignment sheet scores with evaluation ratings on the practical tests.

Written Test Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on the written test.

PAGE NUMBERING

Each publication for the CIMC is assigned a specific abbreviation or will be recognized by the book title. *Manual Drivetrain and Axles Specialist* will be referred to by "MDT." Each unit is identified by the unit number in Roman numerals followed by the page number. The first page of each unit is always page 1. The component name, book title, unit number, and page number within the unit are printed at the bottom of each page. An example of the page footer for an objective sheet in *Manual Drivetrain and Axles Specialist* is shown below.

OBJECTIVE SHEET - MDT
I - 1

METHODS OF DISSEMINATING MATERIAL

Each student should be provided with a student workbook. Workbooks may be purchased for less than an instructor can reproduce them, especially when the instructor's time is considered. Student workbooks contain everything but the suggested activities, pretests, pretest answers, handouts, transparency masters, activity sheet answers, assignment sheet answers, practical tests, written tests, and written test answers. Test packets may be purchased from the Curriculum and Instructional Materials Center. Students should be allowed to take their workbooks home when they complete the program.

TEACHING METHODS

It is a challenge to keep students motivated. Instructors can supplement the objectives by providing the "why," personal experiences, and current information. Preparation for each unit should be determined by how each objective can best be taught. Students should become involved in preparing and planning for each unit.

If the material will be utilized in an individualized instruction situation, instructors should provide opportunities that will allow students to become involved in planning for and being responsible for their own education.

COMPETENCY PROFILES

A competency profile is available for each CIMC publication. Competency profiles document student performance. The profile contains a list of the specific job competencies that a student should achieve before leaving the training program. Profiles should be distributed to students as needed.

DISCLAIMERS, CORRECTIONS AND SUGGESTIONS

Materials

Please note that suggested resources and references listed in this publication existed when this publication was written. CIMC assumes no responsibility for providing these materials and cannot ensure the availability of these materials as individual vendors, manufacturers, and publishers may discontinue these products at any time.

Safety

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. The CIMC assumes no responsibility for any adverse effects resulting directly or indirectly from information, suggested procedures, undetected errors or the reader's misunderstanding of the information presented.

Corrections and Suggestions

If you find any errors in this or other CIMC publications or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. Mail this information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and
  Technical Education
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BASIC SKILLS IN CIMC MATERIALS

Preparing students to enter successfully into today's world of work offers vocational education a substantial challenge. The contemporary workplace is characterized by constant and rapid technological change and by increasing job complexity and skill intensity. Due to rapid technological advancement, the half-life of work skills is now reduced to a bare three to five years. Out of this new workplace environment has arisen a growing awareness of the critical importance of an American workforce armed with the skills necessary to survive in a competitive economy.

One result of this national awareness has been the emergence of a renewed emphasis on basic academic skills in all areas of education. Pressure to increase academic skill development is being placed on education by both legislative action and industry mandate. The Carl D. Perkins Vocational and Applied Technology Education Act of 1990 sets stringent basic skill requirements for vocational education. State legislatures are increasingly requiring basic skills accountability by teachers and school administrators. Graduation exams, minimum competency requirements, and expected learner outcomes are being implemented with increasing frequency. In addition, business and industry are delivering the message clearly to educators that vocational competence now requires increased strength in the basic skills.

The issue of the basic skills currently required in the work place was very successfully addressed in a recent national three-year study conducted jointly by the American Society of Training and Development (ASTD) and the U.S. Department of Labor (DOL). The findings of this study were published in 1990 in the book, *Workplace Basics: The Essential Skills Employers Want.*

The ASTD/DOL research indicates clearly that American employers have discovered that their workforces need a variety of skills that include, but are not limited to, the classic academic trio of reading, writing, and computation. Employers now are also looking for competence in areas such as "learning to learn," problem solving and critical thinking, interpersonal and teamwork skills, oral communication and listening techniques, and the social and personal management skills that demonstrate a capacity for independence and responsibility in on-the-job performance.

It is clear that the requirements of today's business and industry have expanded and re-defined "workplace basics." It is in line with the re-definition and with the competency requirements of current education legislation, that the Oklahoma Department of Vocational and Technical Education has chosen to address "basic skills" in the instructional materials produced by its Curriculum and Instructional Materials Center.

It is not a new development for CIMC materials to contain information and activities which develop basic skills competencies in students undertaking vocational programs. What is new is the specific marking, or flagging, of items in our instruction materials that address basic skills.

To assist teachers and students in identifying activities which promote basic skills development, CIMC has implemented a marking system which uses simple graphic symbols or icons. These icons are located in the left margins of assignment sheets, activity sheets, and job sheets. The following is an explanation of the icons and the kinds of basic skill activities they indicate.

1. **READING SKILLS:** Skills involving use of print resource material for obtaining and applying information.

Current vocational education literature indicates that functional literacy as a workplace basic needs to be defined in terms of reading competencies actually required for job performance. The activities identified with this icon addressing reading skills in CIMC materials deal specifically with developing reading skills in an applied, job-related context. These range from general information-gathering activities to tasks requiring use of specific technical reference materials. Many contain a "learning to learn" aspect which promotes engaging actively and purposefully in vocationally relevant inquiry.

2. **WRITING SKILLS:** Skills involving written communication of processes, information, or ideas.

Tasks identified with this icon promote development of skills in written communications. As with reading skills, the writing skills emphasized in CIMC materials have a vocational context. They include filling out forms, keeping work activity records, writing simple memos and letters, generating more complex reports and articles, and written expression of ideas and concepts related to vocational performance or exploration.

3. **MATHEMATICS SKILLS:** Skills involving computation, calculation, and interpretation of numerical data.

This icon identifies activities which develop vocationally-related skills in computation, measurement and estimation, selection and application of appropriate mathematical processes, and collecting, displaying, or interpreting data.

4. **SCIENCE SKILLS:** Skills involving mastery and application of scientific information or theory.

This icon marks activities which are related to the development of skills in either the physical or biological sciences. These skills stress occupationally-related application of science and technology.

5. **ORAL COMMUNICATION SKILLS:** Skills involving speaking and listening.

Activities marked with this icon promote development of effective speaking and listening. They include practice in such areas as speaking techniques, word choice, non-verbal messages, use of communication media, and using active listening techniques. Many of these activities promote "learning to learn" skills in verbal inquiry.

6. **INTERPERSONAL OR RELATING SKILLS:** Skills involving working and getting along with others.

Activities which deal directly with skills in relating to others are marked with this icon. This includes areas such as multi-cultural awareness, group processes and dynamics, negotiation, dealing with conflict, cooperation and teamwork, values and attitudes, and leadership and motivation.

7. **CREATIVE THINKING AND PROBLEM SOLVING SKILLS:** Skills involving comprehending, applying, analyzing, and developing complex ideas and situations.

This icon identifies activities which stress development of higher-order thought processes such as problem identification and analysis, lateral thinking, evaluating alternatives, developing solutions, examining assumptions, and evaluating outcomes.

8. **EMPLOYABILITY SKILLS:** Skills involving choosing, obtaining, and succeeding in a career.

Activities marked with this icon relate to competencies required to obtain employment and develop a career. These competencies include specific occupational tasks. They also include items such as career analysis and selection, job searching, completing applications and resumes, interviewing, business etiquette, and personal management skills required for job-keeping and maturing in one's work. Examples of the later category include personal presentation, self-discipline, work accuracy, reliability, discretion, punctuality, handling stress, judgment, confidence, etc.

9. **SOCIAL STUDIES SKILLS:** Skills involving investigation and application of social concepts.

This icon marks activities which stress competencies in fields relating to human society and its distribution and relationships. This includes areas such as history, geography, demographics, current events, cross-cultural studies, consumer issues, environmental issues, and ethical concerns in science and technology.

Some activities in CIMC materials develop skills in more than one of the eight basic skill areas. In cases where the relative strengths of the skill elements are clearly discernable, the identification icon used is the one judged to be the primary, or strongest, element in the activity. For some activities, more than one icon is used, indicating equal strength of basic skills components in the activity.

The use of graphic icons to identify basic skills in CIMC instructional materials is the first in a series of steps designed to foster basic skills development in vocational students and accountability for vocational teachers. The Oklahoma Department of Vocational and Technical Education has developed a staged implementation strategy for integrating basic skills into CIMC materials. Additional basic skill elements in future CIMC publications will reflect the advancement of this staged implementation

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OBJECTIVE SHEET

SERVICE DRIVELINES

I

INTRODUCTION

The drivetrain is the automotive system that transports the flow of turning power generated by the engine to the drive wheels. Drivetrain components on a front-engine, rear-wheel drive vehicle connect and disconnect the drivetrain from the engine (clutch); adjust the power to meet driving requirements (transmission); move the power from one place to another (driveline); divide and change the direction of the turning power (differential); and finally, power the drive wheels (drive axles). When there is a problem with the drivetrain on a front-engine rear-wheel drive vehicle, after verifying the complaint and road testing the vehicle, the Drivetrain and Axles Specialist looks first at the driveline. The driveline is not only the source of many common drivetrain problems, but must usually be removed before servicing any other drivetrain component.

PREREQUISITE

Before studying this unit, the student must have successfully completed the core curriculum, *Introduction to Automotive Service*.

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose driveline problems and service the driveline. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Choose the correct definitions for terms associated with the automotive driveline by selecting the correct definition from four choices.
2. Label the components of a rear-wheel drivetrain on an illustration.
3. Match the function of rear-wheel drivetrain components with the name of the component by choosing the correct term from a list of three choices.

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4. Label the components of a driveline on an illustration.

5. Match the names of driveline components to phrases describing the components or giving their functions.

6. Match the names of the two types of drivelines to illustrations or written descriptions of each.

7. Write down at least four of the five methods of controlling driveline vibration.

8. Write down the two methods of eliminating driveline speed fluctuations.

9. Identify the major types of driveline joints and their parts by writing the correct names for given illustrations.

10. Diagnose driveline noise and performance problems. (Assignment Sheet 1)

11. Demonstrate the ability to:

    A. Measure and adjust universal joint angles. (Job Sheet 1)

    B. Check driveshaft runout and adjust minor driveshaft imbalance. (Job Sheet 2)

    C. Remove and replace the driveline. (Job Sheet 3)

    D. Inspect, remove, and replace a simple universal joint. (Job Sheet 4)

    E. Inspect, remove, and replace other driveline joints. (Job Sheet 5)

    F. Check companion flange runout. (Job Sheet 6)

    G. Inspect, remove, and replace a center support bearing. (Job Sheet 7)

PREPARATION

Review unit and plan presentation

- Study the specific objectives to determine the order in which you will present the objectives. Decide whether or not you wish to add additional objectives.
- Review teaching suggestions given in the Delivery section and plan classroom activities.
- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.
- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

Obtain supplemental materials

- Order films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrates job sheet skills. Videotape your own procedures if unable to obtain suitable media.
- Copies of current articles on subjects covered in this unit may be obtained by writing to the Automotive Information Council's Reference Center. They will also conduct a computer search for such articles. See the note in the section on Media for more information about this free service.
- Obtain competency profiles for this unit.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364, 1-800-522-5810, ext. 589 in-state; 1-800-654-4502 out-of-state.

- Note equipment and material needs for completing job sheets.

Prepare classroom and shop

- Display safety signs, posters, and charts that show drivetrain and driveline components and service, etc.

- Have magazine articles, specification guides, service manuals, mock-ups, and other references about drivetrain and driveline components and service available for student use.

- Check tools and equipment against job sheet requirements.

Introduce students to the course

- Give an overview of the course and the total program at your institution.

- Familiarize the students with resources that are available to assist them—library, learning lab, counselors, etc.

- Point out that in the automotive service area, the book titles reflect occupational specialty areas within The National Institute for Automotive Service Excellence's (ASE) certification program and that the books are designed to help them acquire the information and skills needed by a specialist in that area. Distribute and discuss Supplement 1, "ASE Certification."

- Show the filmstrip, *ASE Technician's Certification.*

- Distribute and discuss the introductory section to this book, Use of This Publication, which explains the CIMC format for the materials they will be using.

- Pass out the student competency profiles and have the students fill out the personal information required. Relate the profiles to the objectives.

- Discuss your grading and evaluation methods.

- Explain your class management techniques. Review use of tools, tool check-out procedures, and requirements for student-furnished tools.

- Discuss safety and discipline.

Administer Pretest

- Discuss with the students the purpose of pretesting. Explain that they will be asked to complete a written pretest on each unit and that they will be required to demonstrate assignment sheet competencies and job sheet skills as part of the pretesting process.
- Administer the pretest.
- Use the pretest results to assess student competencies, considering the results as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the introduction to the unit in the Objective Sheet.
- Show the film, *Power Train.*
- Distribute and discuss Supplement 2, "Drivetrain Design," stressing that there are a variety of drivetrain configurations and that this unit, "Service Drivelines," discusses a drivetrain component that is found only on front-engine, rear-wheel drive vehicles.
- Point out that on a front-engine, rear-wheel drivetrain, the driveline must usually be removed before any other drivetrain component can be serviced and that this is why this study begins with the driveline.
- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive Drivetrain and Axles Specialist.
- Show the video, *Automotive Drivetrains*.

Objective 1 Choose the correct definitions for terms associated with the automotive driveline by selecting the correct definition from four choices.

- Show examples of terms where applicable.
- Refer to the illustration to discuss the difference between the terms *power train, drivetrain, driveline,* and *driveshaft.*
- Explain that students will find that these terms are sometimes used interchangeably in different service manuals and automotive materials.

- Discuss the boxed material.

Objective 2 Label the components of a rear-wheel drivetrain on an illustration.

- Show the students the location of actual rear-wheel drivetrain components on a vehicle.
- Use this opportunity to explain the method that will be used in your shop for exposing a vehicle's driveline for service. For example: Twin post hoists, service pit
- Show the students examples of vehicles with different drivetrain configurations and point out their drivetrain components. Compare these with the front-engine rear-wheel drivetrain.
- Combine this objective with Objective 3, discussing the functions of the drivetrain components and pointing out design features that help them function correctly.

Objective 3 Match the function of rear-wheel drivetrain components with the name of the component by choosing the correct term from a list of three choices.

- Explain the term *torque* and show how torque is transferred and manipulated by each drivetrain component.
- Discuss other ways *torque* is used in automotive service.
- Have students discuss what problems would occur if the torque were not manipulated and controlled as it is by each drivetrain component.
- Pair students and have them quiz each other on the identification and functions of rear-wheel drivetrain components.

Objective 4 Label the components of a driveline on an illustration.

- Show students actual drivelines containing both one and two driveshafts and point out the components.
- Encourage students to handle and examine a driveline that has been removed from a vehicle, feeling the weight and how the joints operate.
- Discuss which vehicles commonly have a *split driveshaft*.

- Help students distinguish between major components which are found on all or most drivelines and components such as shaft vibration dampers which are occasionally found on a driveline.

Objective 5 Match the names of driveline components to phrases describing the components or giving their functions.

- Discuss the boxed material, "Driveline Operation."
- Refer to the illustration to discuss how driveline length and angle of operation changes during operation.
- Using actual components, manipulate them to show how each one facilitates driveline operation.
- Show the filmstrip, *Drive Shaft and Universal Joints.*

Objective 6 Match the names of the two types of drivelines to illustrations or written descriptions of each.

- Use the boxed material to explain *rear-end torque.*
- If available, show the students actual examples of both types of drivelines.
- Point out on a vehicle how the transmission is bolted to the chassis, but the differential is attached to the rear springs and suspension.
- Explain the disadvantages of a torque-tube drive driveline, and stress that it is little-used in modern vehicles.
- Discuss *rear-end wrap-up* in Hotchkiss drive vehicles.

Objective 7 Write down at least four of the five methods of controlling driveline vibration.

- Use the boxed material to explain why driveline vibration can be a problem.
- Stress the importance of driveline balance and how the rapid rotation of the driveline magnifies the effect of the smallest imbalance. Demonstrate this by tying a metal nut tightly to the end of a piece of string and swinging it gently in a circle, pointing out that at a slow speed, the nut exerts a gentle pull on the string. Swing the string faster, explaining that at a faster rotation speed, the weight of the nut exerts a much greater pull on the string.

- Explain that during manufacture, the entire driveline is balanced as a unit and point out that except for the use of shorter driveshafts and special driveshaft designs, most methods of controlling vibration can be added after the vehicle is designed, correcting unforseen imbalance.

- Discuss each method of controlling driveline vibration and show actual examples of each.

Objective 8 Write down the two methods of eliminating driveline speed fluctuations.

- Using a driveline with a simple universal joint held by two students, demonstrate *speed fluctuation* in a simple universal joint. Use the boxed material, "Driveline Speed Fluctuation," to help direct your discussion.

- Discuss *constant velocity* as it relates to the driveline and to other automotive functions.

- Explain *phasing* and *cancelling angles*.

- Allow students to handle a double Cardan universal joint to observe its smoother operation.

Objective 9 Identify the major types of driveline joints and their parts by writing the correct names for given illustrations.

- Show students actual driveline joints and let them handle them as you point out the various parts.

- Use the boxed materials to expand your explanations.

- Disassemble several driveline joints and provide name tags for matching with the parts, letting students practice identifying the parts.

APPLICATION

Objective 10 Diagnose driveline noise and performance problems. (Assignment Sheet 1)

- Stress the fact that the two main symptoms of driveline problems, vibration and noise, are also symptoms of a number of other automotive service problems; give examples of such problems.

- Use Supplement 3, "Making a Diagnostic Road Test," to explain road test procedures as a method of diagnosing automotive problems.

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- Use Supplement 3 as a basis for discussing good customer relations. For example, a customer who feels like you have listened to him is more likely to be satisfied with your diagnosis and service.
- Discuss the procedures you will use in your class for making necessary road tests on vehicle. Make the instructions clear, explaining legal restrictions and requirements which apply.
- Explain how drivelines can be inspected during routine service opportunities.
- Discuss the use of Supplement 4, "Driveline Troubleshooting Guide," Supplement 5, "Driveline Vibration and Noise Diagnostic Chart," and Supplement 6, "Driveline Visual Inspection Checklist."
- Demonstrate how to make a visual inspection of the driveline.
- Show the videos, *What Makes It Shake?* and *NVH [Noise, Vibration, Harshness] Vehicle Diagnosis*, and the slides, *Noise, Vibration, and Harshness.*
- Have the students complete Assignment Sheet 1, using Supplement 3, "Making a Diagnostic Road Test," Supplement 4, "Driveline Troubleshooting Guide," Supplement 5, "Driveline Vibration and Noise Diagnostic Chart," and Supplement 6, "Driveline Visual Inspection Checklist."

Objective 11A Measure and adjust universal joint angles. (Job Sheet 1)

- Review your shop procedures for raising a vehicle and exposing its driveline for inspection and service.
- Review safety rules and precautions for working under a vehicle.
- Read and discuss the boxed material on "Using Service Manuals."
- Show how to use an inclinometer and demonstrate several types if they are available.
- Discuss the reasons why universal joint angles on a driveline might change.
- Demonstrate the job sheet procedures for measuring and adjusting universal joint angles.

- Show examples of types of shims and discuss how they are obtained and used in adjusting universal joint angles.
- Go over Supplement 7, "Torquing a Bolt," with the students if you have them adjust the universal joint angles for Job Sheet 1.
- Have students complete Job Sheet 1.

Objective 11B Check driveshaft runout and adjust minor driveshaft imbalance. (Job Sheet 2)

- Stress the safety precautions for working under a vehicle while the driveline is rotating.
- Show the video, "How to Use Automotive Precision Tools," showing how to use a dial indicator.
- Review Supplement 8, "Using a Dial Indicator," and demonstrate how to use a dial indicator to measure runout. Show several types of indicators if available.
- Give the students practice using a dial indicator to make other simple precision measurements in the shop.
- Show the students how to use an electronic wheel balancer to measure runout.
- Use Supplement 7, "Torquing a Bolt," if replacement of the driveline after it is rotated requires bolting the companion flange.
- Demonstrate the job sheet procedures for using hose clamps to adjust minor driveshaft imbalance.
- Have students work in pairs to complete Job Sheet 2.

Objective 11C Remove and replace the driveline. (Job Sheet 3)

- Explain under what conditions the driveline should be removed, pointing out that this procedure is used only as a last resort when diagnosing driveline problems.
- Caution the students about the safety hazard of allowing transmission lubricant (or any lubricant) to leak onto the shop floor.
- Discuss the boxed material on "Matchmarks," and show the students acceptable methods of making matchmarks.

- Show the students where to place matchmarks before removing the driveline.
- Demonstrate how to work with an assistant to remove and replace the driveline.
- Stress the importance of supporting the driveline during removal and replacement, pointing out that unless it is supported properly, removing the driveline can create more problems than it solves.
- Show the filmstrip, *Servicing the Drive Shaft and Universal Joints.*
- Have students work in pairs to complete Job Sheet 3.

Objective 11D Inspect, remove, and replace a simple universal joint. (Job Sheet 4)

- Show examples of bad universal joints and point out the symptoms that lead to this diagnosis.
- Display a sample replacement kit for a simple universal joint.
- Demonstrate the procedure outlined in Job Sheet 4.
- Have the students practice the procedures in Job Sheet 4 until they are prepared to take the practical test.

Objective 11E Inspect, remove, and replace other driveline joints. (Job Sheet 5)

- Show the students how to inspect a double Cardan joint and a slip joint.
- Demonstrate how to file a small burr found on a driveline joint.
- Show the videos, *CV Joints*, *CV-1 Introduction to CV Joints*, and *CV-2 Troubleshooting and Inspection of CV Joints.*
- Discuss the importance of *cost-effectiveness* in making automotive service decisions, and how this principle operates in determining when components should be repaired or replaced.
- Explain what driveline components might be totally replaced if a slip joint or double Cardan joint is damaged.
- Have students complete Job Sheet 5.

Objective 11F Check companion flange runout. (Job Sheet 6)

- Use Supplement 8, "Using a Dial Indicator," to demonstrate how to install a dial indicator on the differential housing to measure companion flange runout.
- Explain the difference between *lateral* runout and *radial* runout and tell why measurements for both are important to correct driveline operation.
- Show students how to measure companion flange runout.
- Explain that if the drive pinion gear is bent or damaged the differential will have to be removed in order to replace this gear. The job sheet procedure for this task is in Unit 2.
- Have the students complete Job Sheet 6.

Objective 11G Inspect, remove, and replace a center support bearing. (Job Sheet 7)

- Give a demonstration of how to remove a center support bearing.
- If students need help in using service manuals to complete the job sheets, review Unit B-1, "Use Automotive Service Reference Materials," in *Introduction to Automotive Service* with them.
- Discuss with the students the variety of center support bearings and show them how to consult a service manual for correct removal and replacement procedures.
- Have the students complete Job Sheet 7.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.
- Evaluate class members on assignment sheet activities if this was not previously done. Provide them with copies of Supplement 3, "Making a Diagnostic Road Test," Supplement 4, "Driveline Troubleshooting Guide," Supplement 5, "Driveline Vibration and Noise Diagnostic Chart," and Supplement 6, "Driveline Visual Inspection Checklist."
- Give the practical tests. Evaluate the tests on forms provided.
- Reteach and retest as required

- Complete the appropriate section of the competency profiles.
- Review individual and group performance in order to evaluate teaching methods.
- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- Abbott, Sheldon L. *Automotive Power Trains*, 2nd ed. Encino, California: Glencoe Publishing Co., 1988.
- *Auto Mechanics II*. Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1978.
- *Axle-Driveshaft Diagnosis and Service*. Detroit, Michigan: Ford Service Publications, 1978.
- *Car 1987 Shop Manual—Powertrain, Lubrication, Maintenance*. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.
- *Chilton's Auto Repair Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- *Chilton's Auto Repair Manual 1985*. Radnor, Pennsylvania: Chilton Book Co., 1984.
- *Chilton's Import Car Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- Crouse, William H., and Donald L. Anglin. *The Auto Book*, 3rd ed. New York: Gregg Division, McGraw-Hill, 1984.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill, 1985.
- Crouse, William H., and Donald L. Anglin. *Automotive Transmissions and Power Trains*, 5th ed. New York: McGraw-Hill, 1976.
- Crouse, William H., and Donald L. Anglin. *Manual Transmissions and Power Trains*, 6th ed. New York: Gregg Division, McGraw-Hill, 1983.
- Crouse, William H., and Donald L. Anglin. *Motor Vehicle Inspection*. New York: Gregg Division, McGraw-Hill, 1978.

- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- Erjavec, Jack. *Manual Transmissions and Transaxles*. New York City, New York: Harcourt Brace Jovanovich Technology Publications, 1990.
- Hughes, James G. *Guide to Automobile Certification Examination*, revised ed. Reston, Virginia: Reston Publishing Co., Inc., a Prentice-Hall Company, 1983.
- *Introduction to Automotive Service*. Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1989.
- Kovacik, Robert T., and Clifford Creager. *Manual Transmissions and Drivetrains*. Cincinnati, Ohio: South-Western Publishing Co., 1984.
- Limpert, Rudolf. *Motor Vehicle Accident Reconstruction and Cause Analysis*, 2nd ed. Charlottesville, Virginia: The Michie Company, Law Publishers, 1984.
- Mitchell Information Services, Inc. *Mitchell Automechanics*. Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- 1986 Camaro Shop Manual. Detroit, Michigan: General Motors Corp., 1985.
- *Official ASE Preparation Guide to ASE Automobile Tests, The*. Reston, Virginia: National Institute for Automotive Service Excellence, 1989.
- *Rear Axles and Drive Shafts*. Detroit, Michigan: General Motors Corp., 1987.
- *Service Manual—Spicer Universal Joints and Driveshafts*. Toledo, Ohio: Dana Corp., Drivetrain Service Division.
- *Spicer Driveline Components—Troubleshooting Guidelines*. Toledo, Ohio: Dana Corp., Drivetrain Service Division.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1982.

- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.

- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1983.

- "Universal Joints and Driveshafts—Nomenclature—Terminology—Application Guidelines." *1989 SAE Handbook, Volume 4*. Warrendale, Pennsylvania: Society of Automotive Engineers, 1989.

- Webster, Jay. *Auto Mechanics*, 2nd ed. Encino, California: Glencoe Publishing Co., Inc., 1986.

- Webster, Jay. *Automotive Power Train Systems*. Homewood, Illinois: American Technical Publishers, Inc., 1982.

- White, John H. *Manual Transmissions and Drivetrains*. Albany, New York: Delmar Publishers Inc., 1987.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *ASE Technician's Certification*. 12 minutes, filmstrip. Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565. Covers the necessary information needed to become a qualified technician in the automotive trade. Explains how to prepare for tests, whom to contact regarding testing schedules. Encourages tradespeople to join ASE and tells of the advantages of membership.

- *Automotive Drivetrains*. 15 minutes, color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Introduction to the function and operation of the drivetrain and its components, including transmissions, transaxles, clutches, driveshafts and rear axles.

- *Automotive Information Council—Reference Center.* 13505 Dulles Technology Drive, Herndon, Virginia 22071-3415, phone (703) 904-0700. The AIC Reference Center has a reference base of over 10,000 volumes, maintaining subscriptions to over 100 trade and consumer publications relating to the automotive industry. Their computer indexing system can provide educators with up-to-date print-outs of books, articles from periodicals, statistical abstracts, press releases, catalogues, and other reference materials on 90 automotive subject classifications. AIC's services are free of charge. Copies of current articles from periodicals are also available free if requested in nominal quantities.

- *C.V. Joints.* 20 minutes, video. Moog. Automotive Service Association, P.O. Box 1047, Bedford, Texas 76095-1047, phone (817) 283-6205. Describes diagnosing and replacing CV joints.

- *CV-1 Introduction to CV Joints.* 14 minutes, video. Perfect Circle. Automotive Service Association, P.O. Box 1047, Bedford, Texas 76095-1047, phone (817) 283-6205. Includes a brief history, an overview of the various types of CV joints and the theories behind their operation, and a discussion of the specific CV joint service programs available.

- *CV-2 Troubleshooting and Inspection of CV Joints.* 8 minutes, video. Perfect Circle. Automotive Service Association, P.O. Box 1047, Bedford, Texas 76095-1047, phone (817) 283-6205. Three basic areas of troubleshooting and inspection: road test, visual inspection, and wheel spin test.

- *Drive Shaft and Universal Joints.* 12 minutes, filmstrip. National Innovative Media, Route #2, Box 301B, Calhoun, Kentucky 42327, phone 1-800-962-6662, or (502) 273-5050 in Kentucky.

- *How to Use Automotive Precision Tools.* 11-14 minutes each, 4-part video or filmstrips. National Innovative Media, Route #2, Box 301B, Calhoun, Kentucky 42327, phone 1-800-962-6662 or (502) 273-5050 in Kentucky. Covers the following tools: dial gauge, inside micrometer, feeler gauge, cylinder dial gauge, outside micrometer, and torque wrench.

- *Noise, Vibration and Harshness.* 50 color slides, 58 p. Instructor Guide, and 46 p. Student Text. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. The object of this text is to improve mechanical skills, to increase the accuracy of diagnosis and to provide time-saving procedures for the identification and elimination of problems relating to vehicle noise, vibration and harshness.

- *NVH Vehicle Diagnosis.* 26 minutes, color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Defines noise, vibration, and harshness concerns; provides diagnostic theory and repair procedures in step-by-step format.

- *Servicing the Drive Shaft and Universal Joints.* 2 Parts: *Removing and Disassembling a Drive Shaft and Universal Joints* and *Assembling Universal Joints and Installing the Drive Shaft.* 2 filmstrips. Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050, phone 1-800-431-1242. Shows how to examine, remove, and replace the universal joints and driveshaft.

- *What Makes It Shake?* video. General Motors Service Training Development Information, Kent Moore Tool & Equipment Division, SPX Corporation, 28635 Mound Road, Warren, Michigan 48092-9923, phone 1-800-468-6657. Information on vibration diagnosis.

NOTE: The following 16 mm film is available to Oklahoma teachers on a free-loan basis. Out-of-state teachers must order from the address listed.

- *Power Train.* 13 minutes, color 16mm film. Filmfair Communications. Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Cartoon about basic gears, the transmission, clutch, universal joint, drive shaft, and differential.

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions:

Objective	Question
1	1,2
2	3
3	4
4	5
5	6
6	7
7	8
8	9
9	10
10	11, 12
11A	13
11B	14
11C	15
11D	16
11E	17
11F	18
11G	19

ANSWER KEY

1. C
2. B
3. C
4. A
5. C
6. D
7. B
8. D
9. B
10. B
11. C
12. B
13. A
14. C
15. B
16. B
17. A
18. D
19. D

SERVICE DRIVELINES

NAME ______________________________ SCORE ______

DIRECTIONS

Read the following questions and problems, then circle the letter before the item that best answers the question or solves the problem.

______1. All of the following are true about double Cardan joints **except**:

A. They transmit torque at a constant speed
B. They operate at an angle
C. They allow the driveline to alter its length during operation
D. They rotate during operation

______2. Rear-end torque:

A. Is caused by universal joints operating at the wrong angle
B. Causes the differential and axle housing to twist
C. Is what the engine's turning power is called when it operates the drive-axles
D. Is a result of an unbalanced driveline

______3. Which of the following is **not** a component of a front-engine, rear-wheel drivetrain?

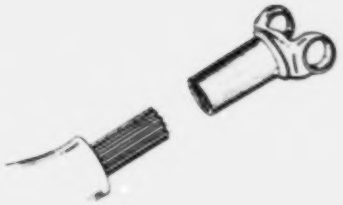
A. Clutch
B. Transmission
C. Transfer case
D. Drive axles

______4. Which component distributes the turning power to the drive axles in a rear-wheel drivetrain?

A. Differential
B. Driveline
C. Transmission
D. Driveshaft

______5. What driveline component is pictured?

A. Center support bearing
B. Constant-velocity joint
C. Slip joint
D. Universal joint



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______6. Which statement is **not** true about drivelines?

A. They are able to lengthen and shorten
B. They can transfer power at an angle
C. They transfer power over a distance
D. They are found on all vehicles

______7. In a Hotchkiss drive driveline, rear-end torque is controlled by:

A. Bracing the driveline inside a hollow tube
B. Rear suspension and springs
C. Control bars bolted to the chassis
D. Slip joints

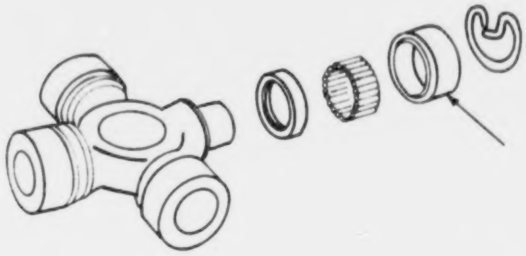
______8. There is a solid rubber ring surrounding a driveshaft. What is its purpose?

A. To control rear-end wrap-up
B. To support the driveline
C. To balance the driveshaft
D. To control vibration

______9. Which of the following would control driveline speed fluctuations?

A. Damper ring
B. Double Cardan joint
C. Universal joint
D. Driveshaft balance weights

_____10. Identify the indicated part of a simple universal joint:



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A. Trunnion
B. Bearing cup
C. Retainer ring
D. Seal

_____11. Driveline vibration could be caused by all of the following **except**:

A. Undercoating on the driveline
B. Dry U-joint
C. Slip joint sliding back and forth in the transmission extension housing
D. U-bolt too tight

_____12. Which of the following is **not** correct?

A. Noise and vibration are common symptoms of driveline problems
B. The driveline should be removed for proper diagnosis of driveline problems
C. Cleaning the driveline can eliminate vibration
D. A road test can help diagnose driveline problems

_____13. How is an inclinometer used?

A. To measure the operating angle of U-joints
B. To measure the angle between the front and the rear of the driveline
C. To measure driveshaft runout
D. To detect a bent driveshaft

_____14. How are hose clamps used on the driveshaft?

A. To replace a missing driveshaft balance weight
B. To reduce driveline speed fluctuation
C. To correct a minor imbalance
D. To secure a driveshaft vibration absorber

_____15. Technician A says you should remove only the damaged driveline component in order to replace it. Technician B says you must always remove the entire driveline before you remove any damaged component. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____16. A simple universal joint needs to be replaced if:

A. It is operating at the wrong angle
B. There is brinelling on its trunnions
C. There is no looseness between its spider and yokes
D. Both A and B

_____17. When a double Cardan joint is damaged, Technician A wants to replace the entire driveline and Technician B wants to replace the damaged part of the joint. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____18. Which procedure might correct companion flange runout if it does not measure within specifications?

A. Reinstalling the companion flange 180° from its original position
B. Replacing the companion flange
C. Replacing the drive pinion gear
D. All of the above

_____19. Which of the following is **not** true?

A. There are many types of center support bearings
B. The center support bearing should be replaced as a unit
C. The driveline must be removed in order to replace a center support bearing
D. Repacking the bearings is the simplest way of solving center support bearing problems

SERVICE DRIVELINES

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive driveline by selecting the correct definition from four choices.

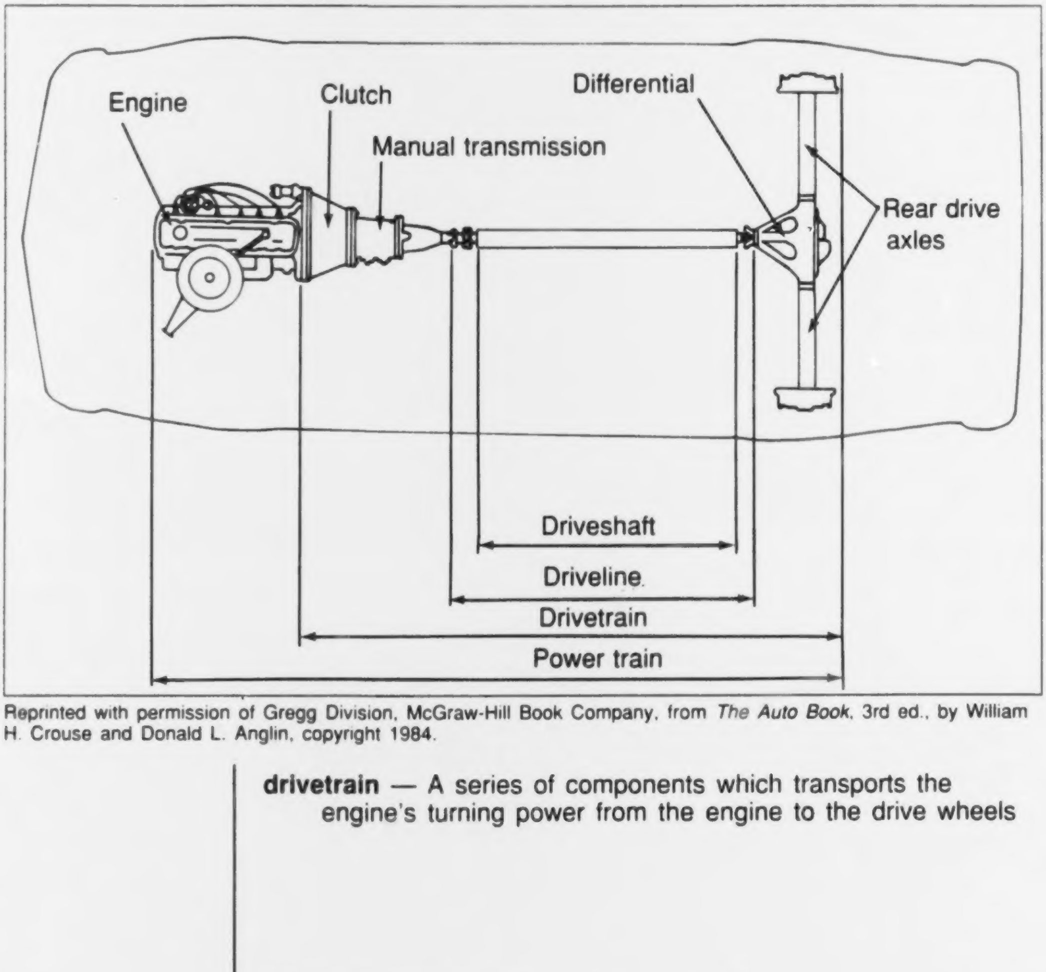
constant velocity joints — Joints which maintain a constant speed of rotation regardless of the angle of operation

driveline — The drivetrain component that transports torque over a distance from the transmission to the differential on a front-engine, rear-wheel drive vehicle

driveshaft — A hollow tube, part of the driveline, which transfers torque across distance; also called a ***propeller shaft***

EXAMPLE:

FIGURE 1


Engine
Clutch
Manual transmission
Differential
Rear drive axles
Driveshaft
Driveline
Drivetrain
Power train

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drivetrain — A series of components which transports the engine's turning power from the engine to the drive wheels

matchmarks — Lines marked across from each other on two adjacent components or parts so that when the parts are reassembled they can be placed in their original position

power train — The circuit of power beginning with and including the engine and ending with the drive wheels

rear-end torque — The powerful twisting action the driveline exerts on the differential and rear axle housing

runout — The distance the surface or edge of a rotating part moves in or out during rotation

speed fluctuation — Speeding up and slowing down in a component which should operate at an even speed

split driveshaft — A driveline containing two or more driveshafts

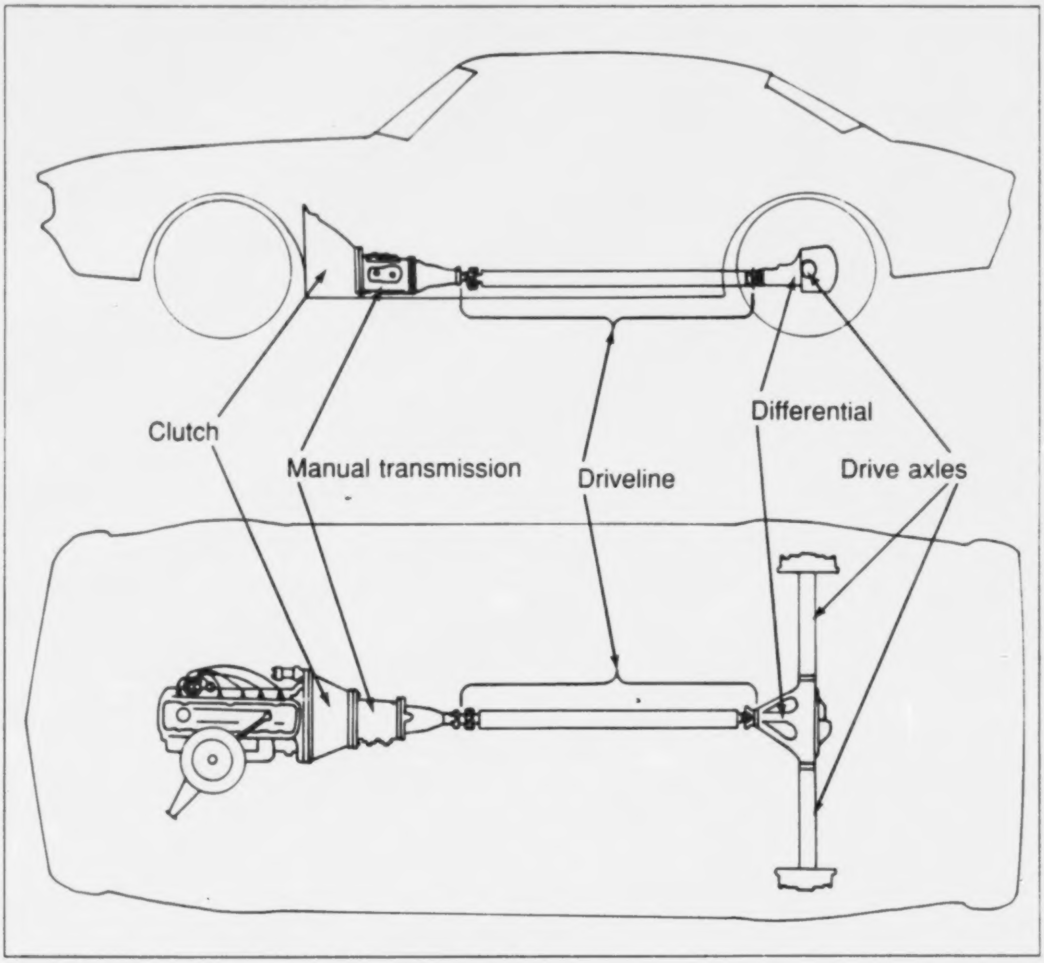
torque — Turning power

universal joint — A type of joint which transmits torque while allowing for angle changes; also called a ***U-joint***

Historically, auto mechanics skills have been taught through oral rather than written instruction. Because of this, the spelling of terms used in the field has not been standardized. Words used in this book are often spelled differently in other books.

OBJECTIVE 2 **Label the components of a rear-wheel drivetrain on an illustration.**

FIGURE 2


Clutch
Manual transmission
Driveline
Differential
Drive axles

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NOTE: The clutch, manual transmission, differential, and drive axles are located inside the housings shown in the illustration.

OBJECTIVE 3

Match the function of rear-wheel drivetrain components with the name of the component by choosing the correct term from a list of three choices.

5 COMPONENTS OF A REAR-WHEEL DRIVETRAIN

Drivetrains are designed in a number of possible configurations, but the front engine, rear-wheel drivetrain which includes a manual transmission is commonly called a "conventional" or "traditional" drivetrain. Its five components form a circuit through which turning power, called ***torque***, generated by the engine is transferred to the drive wheels and used to propel the vehicle. The drivetrain components, however, do more than just transport this power.

The rear-wheel drivetrain components are listed here in the order of power flow from the engine.

1. **clutch** — A drivetrain component that connects and disconnects the engine from a manual transmission or transaxle

2. **transmission** — A series of gears that multiplies and adjusts the engine's torque to driving requirements before transmitting it to the driveline

3. **driveline** — The drivetrain component that transports torque over a distance from the transmission to the differential

4. **differential** — A gear assembly that accepts the torque from the driveline and divides and distributes it to the drive axles in such a way that the axles are able to turn at different speeds when turning a corner

5. **drive axles** — The shafts that transmit the torque from the differential or the transaxle to the drive wheels to propel the vehicle

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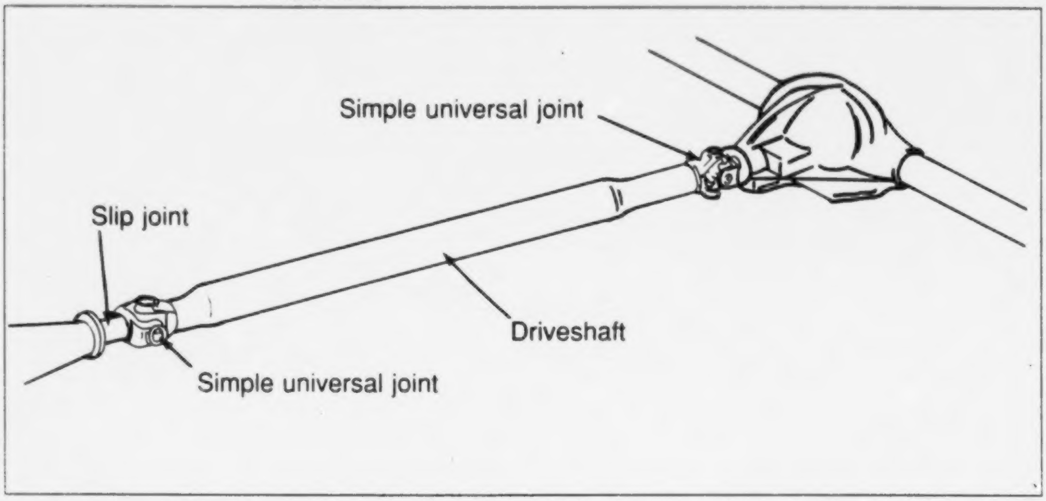
OBJECTIVE 4 **Label the components of a driveline on an illustration.**

FIGURE 3


Simple universal joint
Slip joint
Driveshaft
Simple universal joint

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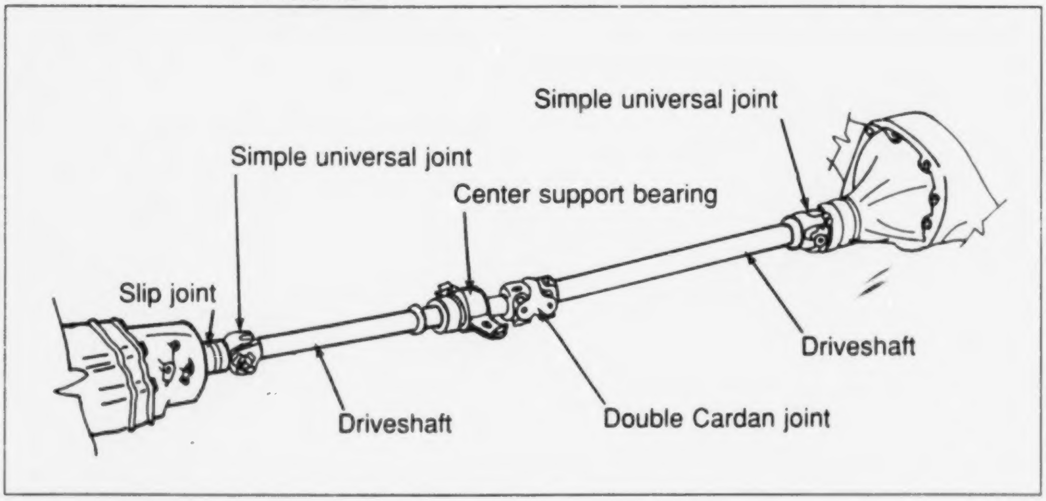
NOTE: Most drivelines consist of a single driveshaft with a universal joint at the front and rear. A slip joint connects the front universal joint to the transmission. (Figure 3)

FIGURE 4


Simple universal joint
Simple universal joint
Center support bearing
Slip joint
Driveshaft
Driveshaft
Double Cardan joint

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NOTE: Some trucks and large cars have a driveline with two or more driveshafts, called a ***split driveshaft***. (Figure 4)

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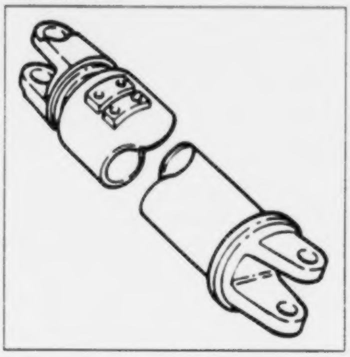
OBJECTIVE 5 **Match the names of driveline components to phrases describing the components or giving their functions.**

- The **driveshaft**, sometimes called a ***propeller shaft***, transfers torque across distance. Most driveshafts are a thin-walled, hollow metal tube with permanent yokes welded on each end. (Figure 5)

  NOTE: Solid metal driveshafts are found on a few European imports. Some recent driveshafts have been made of a fiber composite material which results in a shaft which is quiet, lightweight, and better balanced.

EXAMPLE:

FIGURE 5



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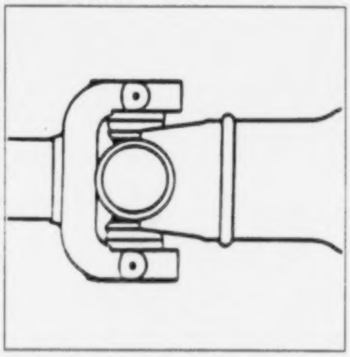
- A **universal joint**, usually called a ***U-joint***, allows the driveline to adjust to angle changes between the transmission and differential while continuing to transmit torque. A simple universal joint consists of a cross-shaped centerpiece which swivels between two separate sets of yokes. (Figure 6)

EXAMPLE:

FIGURE 6



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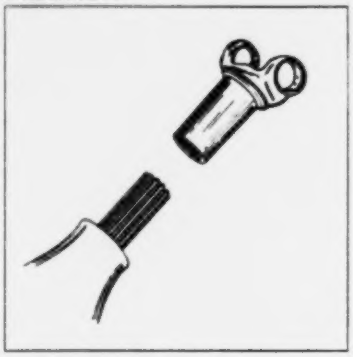
- A **slip joint** shortens or lengthens to allow the driveline to adjust to distance changes between the transmission and differential. Its simple construction consists of a shaft which slips into a tube. (Figure 7)

EXAMPLE:

FIGURE 7



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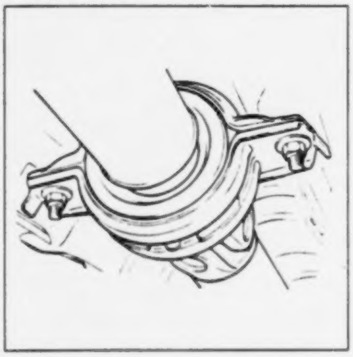
- A **center support bearing** supports the driveline and allows it to rotate easily. A sealed prelubricated bearing assembly surrounded by rubber insulation, it circles the driveshaft and is bolted to the chassis. Center support bearings are most often found on drivelines which have a split driveshaft. (Figure 8)

EXAMPLE:

FIGURE 8



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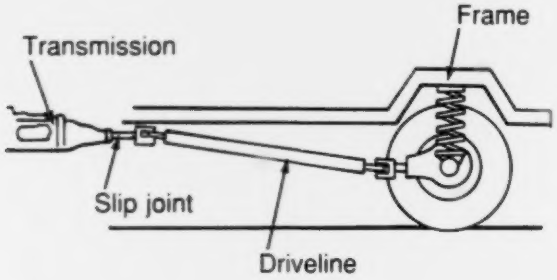
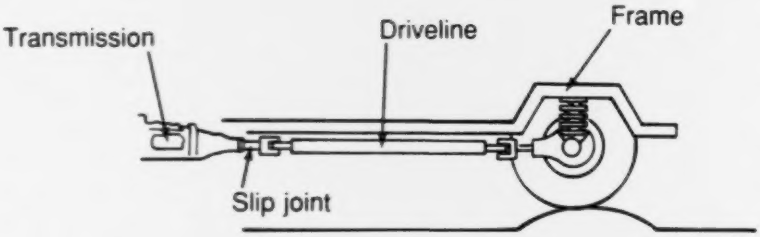
DRIVELINE OPERATION





Transferring torque smoothly over the distance between the transmission and the differential is complicated by the fact that the transfer must be made in a moving vehicle. Although the engine and transmission are bolted to the vehicle chassis and are relatively immovable, the rear suspension and springs are constantly adjusting for bumps and turns, acceleration and deceleration, and both the angle and the distance between the transmission and differential is constantly changing.

In order to operate properly, the driveline must:

- transmit turning power from the transmission to the differential
- allow for the up and down movement of the rear axle
- be able to lengthen or shorten itself to adjust to changes in distance
- maintain a smooth power flow while performing these functions

The special design of its components allows the driveline to meet these operating requirements.

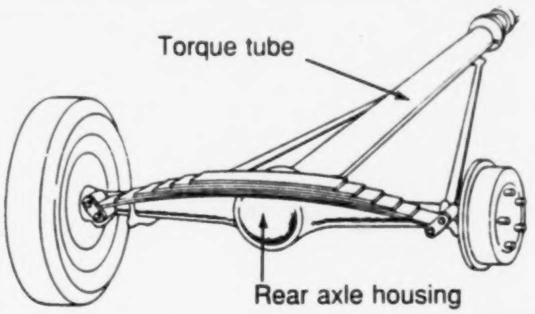
OBJECTIVE 6 **Match the names of the two types of drivelines to illustrations or written descriptions of each.**

REAR-END TORQUE

When the driveline transfers torque to the drive axles, the turning power changes direction 90°. This change is accomplished by gears within the differential. But as this power changes direction, something else happens—the vehicle begins to move. The power that has up to now been turning only gears and shafts begins to propel an object at rest, weighing hundreds of pounds. The force of this moving, changing torque has a powerful twisting action on the entire differential housing. This action is called ***rear-end torque*** and controlling it has led to the development of two main types of drivelines.

Torque-Tube Drive

FIGURE 9



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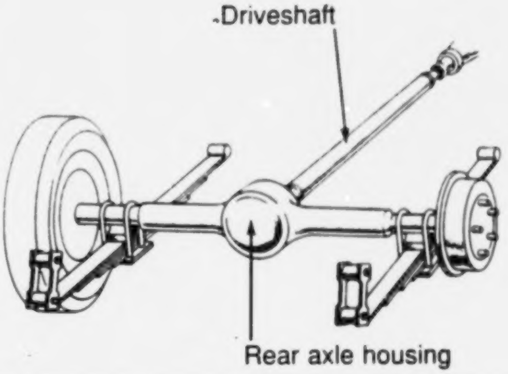
- In a ***torque-tube*** drive, a driveline with a solid steel driveshaft rotates inside a hollow metal tube which is bolted to the differential housing. This tube keeps the driveline in constant alignment with the differential and absorbs rear-end torque. The only U-joint on a torque-tube drive is found in combination with a slip joint at the front end of the driveshaft. (Figure 9)

  NOTE: Because of its weight and the fact that the entire driveline and rear axle must be removed in order to service any part of the drivetrain, almost no modern vehicles except the Chevette use a torque-tube drive.

Hotchkiss Drive

FIGURE 10



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- In a ***Hotchkiss*** drive, the driveline remains open and rear-end torque is absorbed by the vehicle's rear suspension and by the use of universal joints at both the front and rear of the driveline. (Figure 10)

OBJECTIVE 7 **Write down at least four of the five methods of controlling driveline vibration.**

DRIVELINE VIBRATION

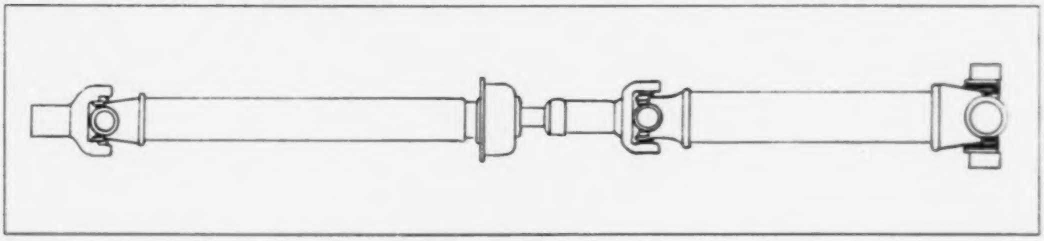
Because the driveline is a long narrow component which rotates at high speeds, it is open to excessive vibration which not only causes noise and extra wear on parts but also make it difficult to maintain good performance and a smooth ride. To control driveline vibration, automotive engineers design the driveline to minimize vibration and use special components to absorb vibration when it does occur.

- **Shorter driveshafts**

  NOTE: A shorter driveshaft is less apt to vibrate than a long one. On vehicles that need a long driveline, engineers will often use two shorter driveshafts rather than one long shaft. (Figure 11)

  EXAMPLE:

FIGURE 11



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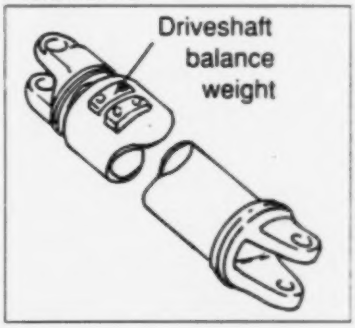
- **Driveshaft balance weights**

  NOTE: Weights are often welded to the driveshaft at the factory to balance it. (Figure 12)

EXAMPLE:

FIGURE 12



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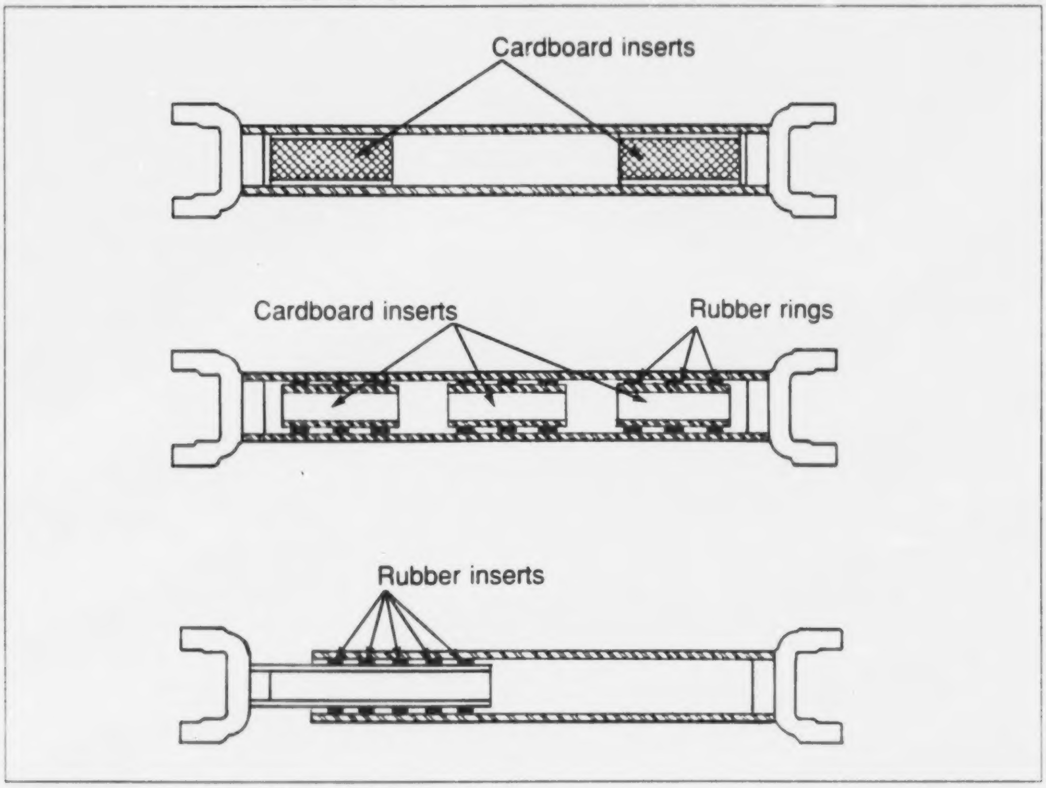
- **Special driveshaft designs**

  NOTE: Driveshafts may be laminated with a solid rubber sleeve or use layers of cardboard and rubber inserts or rubber rings called biscuits to both balance the driveshaft and absorb vibration and noise. (Figure 13) Some driveshafts are filled with a foam which absorbs vibration.

  EXAMPLE:

FIGURE 13


Cardboard inserts
Cardboard inserts
Rubber rings
Rubber inserts

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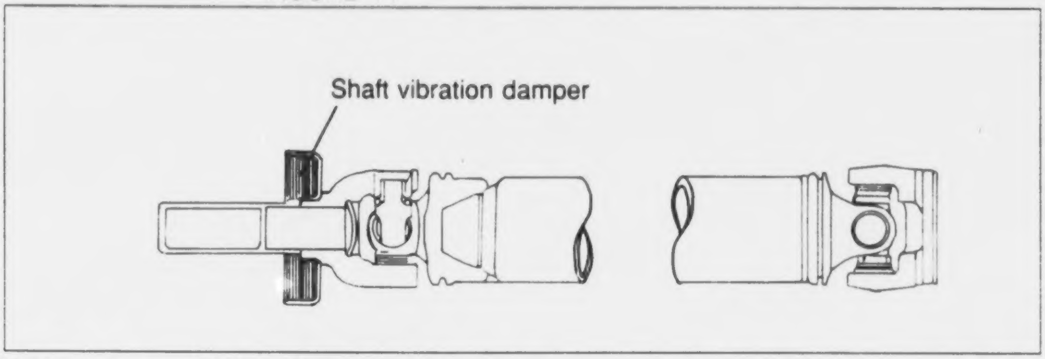
- **Shaft vibration damper**

  NOTE: Sometimes called a ***torsional damper***, a shaft vibration damper is a rubber ring or assembly that absorbs driveline vibration. (Figure 14) Shaft vibration dampers come in several designs.

  EXAMPLE:

FIGURE 14



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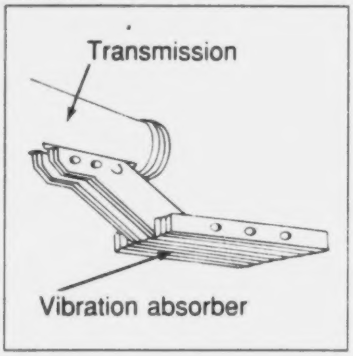
- **Vibration absorber**

  NOTE: Although it is usually attached to the lower rear part of the transmission housing, a ***vibration absorber***, is another device which is used to absorb driveline vibration. (Figure 15) Installing a vibration absorber is usually the cheapest and least complicated method of controlling driveline vibration. Vibration absorbers are occasionally installed on the rear axle housing.

EXAMPLE:

FIGURE 15



OBJECTIVE 8 **Write down the two methods of eliminating driveline speed fluctuations.**

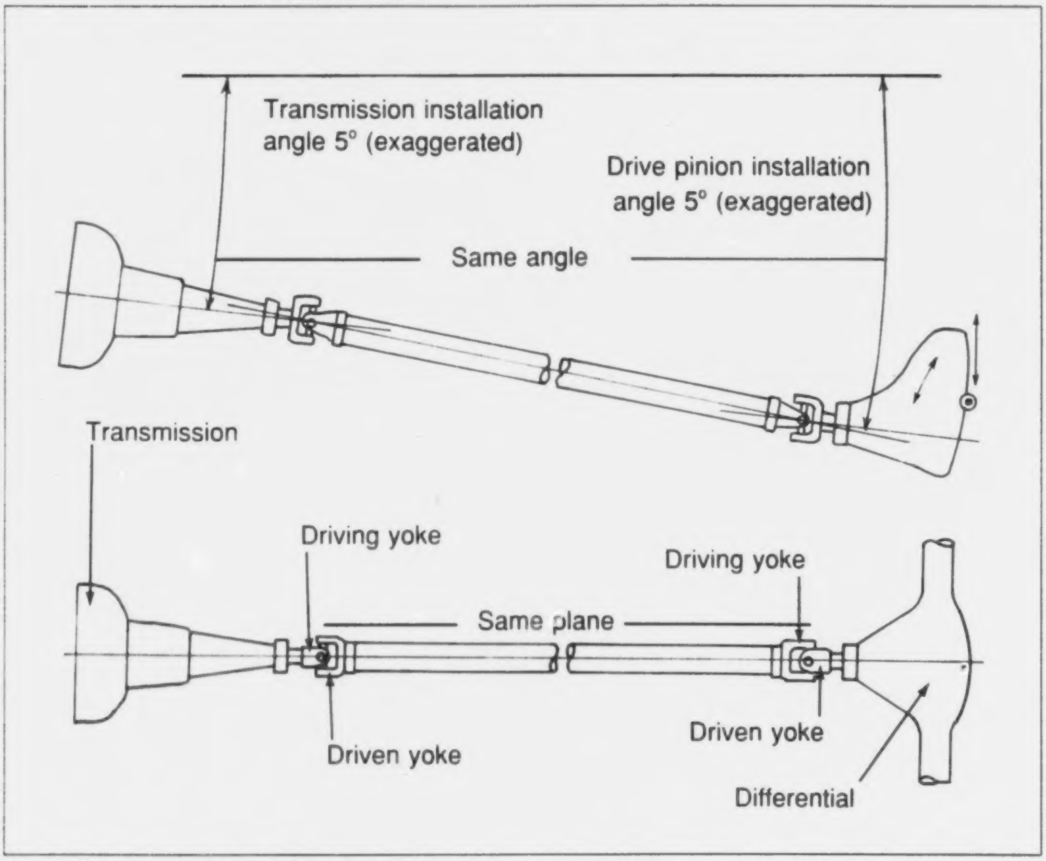
DRIVELINE SPEED FLUCTUATION

Universal joints are designed to operate at an angle. However when they do, even though the driving joint operates at a constant speed, the speed of the driven joint will *fluctuate*, speeding up and slowing down as it rotates. The greater the angle at which the joint is operating, the greater will be the fluctuation. This ***speed fluctuation*** results in uneven power flow and driveline vibration. To operate properly, drivelines should rotate at a uniform speed, or ***constant velocity***. There are two common methods used to eliminate driveline speed fluctuations.

- **Phase the universal joints and have them both operate at the same angle**

EXAMPLE:

FIGURE 16


Transmission installation angle 5° (exaggerated)
Drive pinion installation angle 5° (exaggerated)
Same angle
Transmission
Driving yoke
Driving yoke
Same plane
Driven yoke
Driven yoke
Differential

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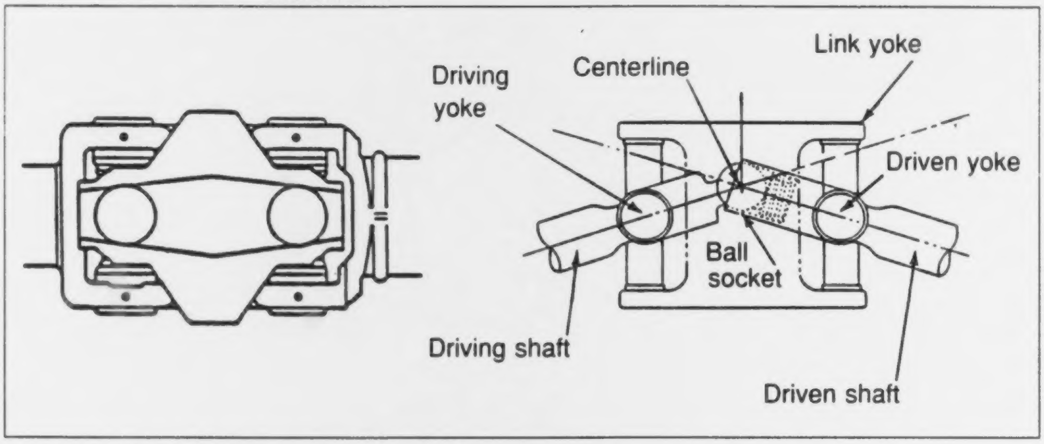
NOTE: On most drivelines, speed fluctuation is controlled by (1) aligning the universal joints on either end of the driveshaft so they are lined up in the same plane, *and* (2) making sure both the front and the rear universal joint are operating at the same angle. Aligned in this way, fluctuations started in the front U-joint are largely cancelled out by the rear U-joint. Aligning the universal joints in the same plane is called ***phasing*** the U-joints. Manufacturers often mark driveline components with arrows so that when assembled, they are properly phased. When the operating angles of the front and the rear universal joints are the same, they are called ***cancelling angles***.

- **Constant velocity universal joints**

EXAMPLE:

FIGURE 17



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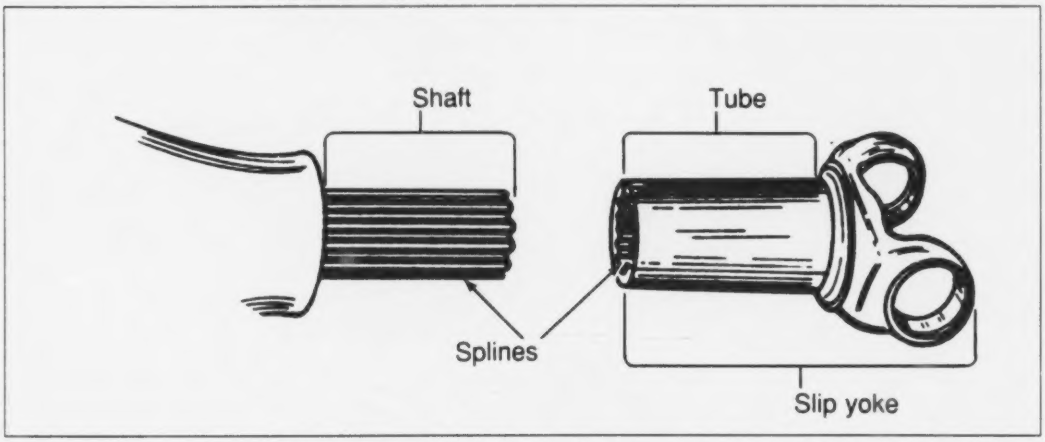
NOTE: Even when properly angled and phased, the simple universal joint can only operate at a very small angle (maximum = 3°-4° from horizontal). When the universal joint must operate at a larger angle, one or more ***constant velocity joints*** may be used. (Figure 17) Constant velocity joints maintain a constant speed of rotation regardless of the angle. The type of near constant velocity universal joint used in drivelines is the ***double Cardan joint***. In the double Cardan joint, two simple universal joints are connected by a centering yoke containing a ball and socket. Because there are two joints instead of one, the angle of operation is split—each joint handling one-half of the needed angle. (Double Cardan joints can usually operate at a 5°-7° operating angle.) Speed fluctuations started by the drive yoke are *immediately* corrected by the driven yoke which is a part of the same assembly.

OBJECTIVE 9 **Identify the major types of driveline joints and their parts by writing the correct names for given illustrations.**

Slip joints

FIGURE 18



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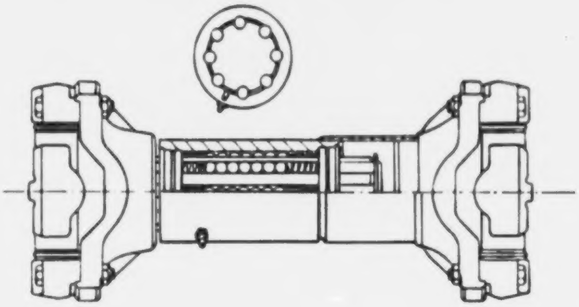
NOTE: Although one or more slip joints can be placed anywhere along the driveline, a slip joint is almost always the first driveline component, joining the transmission to the driveline. (Figure 18) On the outside of the ***shaft*** and on the inside of the ***tube*** are machined ridges called ***splines***. When the shaft is slipped into the tube, the splines mesh and allow the shaft and the tube to rotate together while at the same time allowing them to slide together or apart, adjusting the driveline length. It is important that a slip joint shaft be slipped into the tube at exactly the same point to insure that attached parts such as yokes are aligned properly. The manufacturer will sometimes place arrows to show the correct alignment, or one spline (called a ***master spline***) may be wider than the others, forcing the correct alignment. Often the slip joint at the transmission end of the driveline is called a ***slip yoke***—because a yoke for the first universal joint is attached.

SPECIAL SLIP JOINTS

Two special types of slip joints have been designed for some heavy-duty or high-performance situations. The bearings used in both designs greatly reduce friction as the slip joint slides back and forth.

Instead of having splines, the ***ball-bearing slip joint*** uses spring-loaded balls which roll in shallow grooves between the slip joint's shaft and tube.



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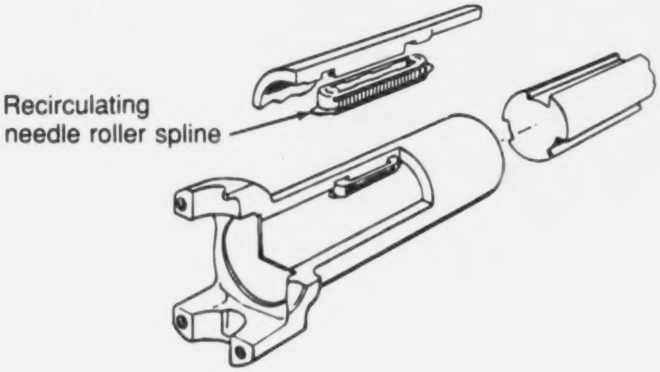
On the inside of the tube of a ***needle-bearing slip joint***, there are sections of needle-bearings which allow a smooth sliding action. Notice that instead of splines, this type of slip joint has several large rectangular grooves called ***keys***, which mesh the shaft and tube.



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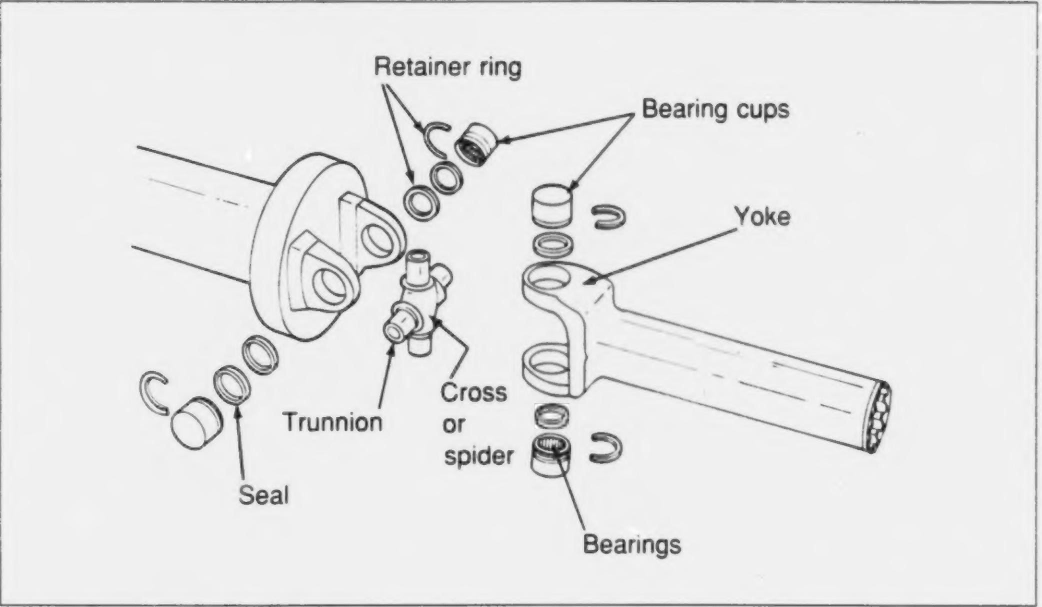
Simple Universal Joint

FIGURE 19


Retainer ring
Bearing cups
Yoke
Cross
or
spider
Trunnion
Seal
Bearings

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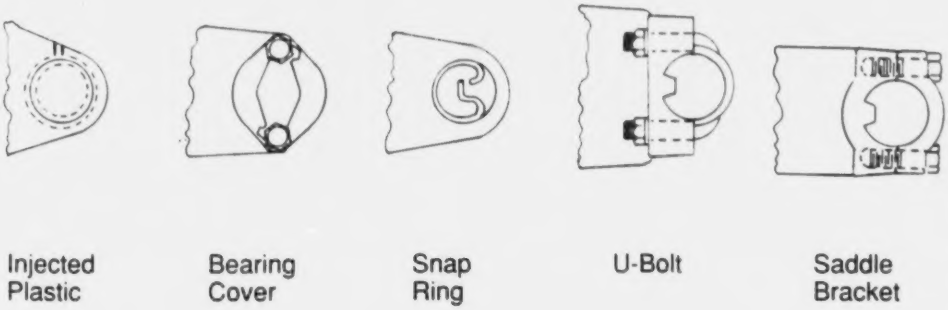
NOTE: Simple universal joints are also called ***Cardan*** joints, ***cross***, ***cross-and-yoke***, ***cross-and-two-yoke***, ***cross-and-roller***, ***Hooke***, or ***spider*** joints. (Figure 19)

Methods of Holding Bearing Cups in Yokes


Injected
Plastic
Bearing
Cover
Snap
Ring
U-Bolt
Saddle
Bracket

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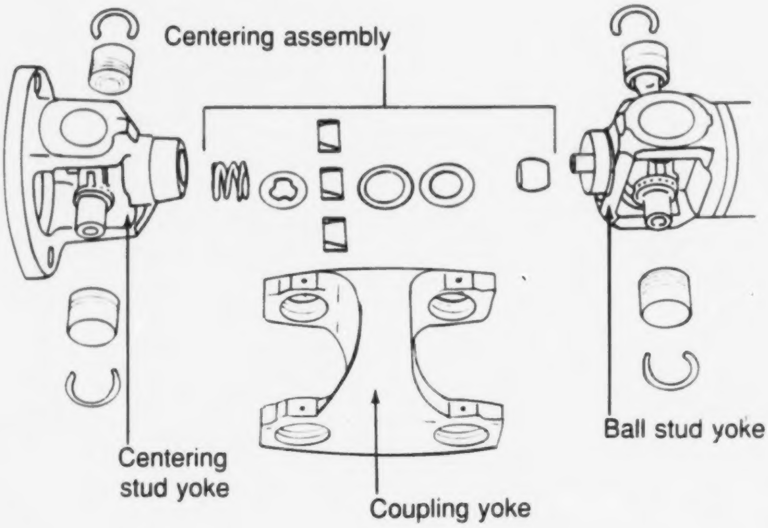
Double Cardan Joint

FIGURE 20


Centering assembly
Ball stud yoke
Centering stud yoke
Coupling yoke

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NOTE: A double Cardan joint is a type of joint known as a ***constant velocity joint*** since it transfers torque at a more even speed than a simple universal joint. (Figure 20) Although a double Cardan joint may sometimes be called a constant velocity joint, the terms are not interchangeable. There are several types of constant velocity joints besides the double Cardan.

ASE CERTIFICATION

National Institute for Automotive Service Excellence

The National Institute for Automotive Service Excellence (ASE) is a nonprofit corporation dedicated to improving the quality of automotive service and repair. ASE's primary method for promoting quality is through voluntary certification of technicians and automotive training programs. Working with representatives from all sectors of the automotive industry, training facilities, government agencies, and consumer groups, ASE has set up a certification program with high standards. In the process, they have identified the eight occupational specialties listed below. Your instructor can provide you with information about ASE and can arrange for you to talk to ASE-certified technicians. You can also get more information by writing to: ASE, 13505 Dulles Technology Drive, Herndon, Virginia 220701-3415, or calling (703) 787-8833.

Eight ASE Automobile Service Specialties:

Engine Repair Technician—Services mechanical portions of engine and related components used to start and run the engine, lubricate it, cool it, and remove exhaust

Automatic Transmission/Transaxle Technician—Services the hydraulic and mechanical systems, controls, and linkages for automatic transmissions and transaxles

Manual Drivetrain and Axles Technician—Services clutches, shafts, joints, gear systems for manual transmissions and transaxles, and final drives on rear-wheel drive vehicles

Suspension and Steering Technician—Services suspension, manual and power-steering components, and tire and wheel assemblies

Brakes Technician—Services mechanical and hydraulic components for disc and drum brake systems

Electrical Systems Technician—Services battery, starting, charging, lighting, signaling, and instrumentation systems as well as electrically operated accessories

Heating and Air-Conditioning Technician—Services mechanical, electrical, and fluid components for the refrigeration, heating, and ventilating systems

Engine Performance Technician—Services ignition, fuel, emission control, cooling, and related mechanical and electrical systems for efficient engine performance, with focus on general automobile diagnostic procedures

Steps for ASE Certification:

- Complete two years of hands-on work experience or one year of hands-on experience and a period of ASE-accepted training

Substitutes for Work Experience

ASE recognizes the value of training and will accept training as a substitute for one year of hands-on experience. Training may consist of any of the following or a combination of the following:

High school training — three full years if successfully completed
Post high school training — two full years
Short courses — two months of short course will be accepted for one month of hands-on experience

- Apply for certification

- Pass ASE test

  NOTE: ASE gives tests in each of the eight specialty areas twice each year.

- You may take the tests prior to completing the work-experience requirement, but a certificate will not be issued until both requirements have been met

- Pass all eight tests to be certified as a ***Master Automobile Technician***

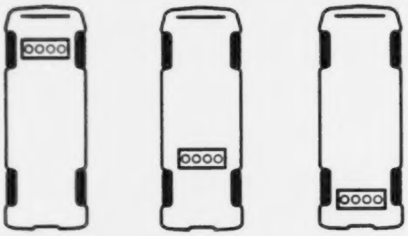
- Recertify every five years by completing a recertification test

  NOTE: Recertification tests are given twice each year for each occupational area. Recertification tests contain half as many questions as the initial certification tests and are required to maintain certification.

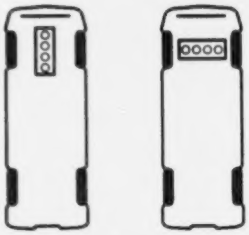
DRIVETRAIN DESIGN

When automotive engineers design cars and trucks, they must always consider a variety of factors such as performance, safety, size, weight, fuel economy, and production cost, as well as customer preferences for style, interior space, comfort, and other design features. As a result, the drivetrain, along with other automotive systems and features, comes in a variety of different configurations. The Drivetrain and Axles Specialist needs to be familiar with these design possibilities.

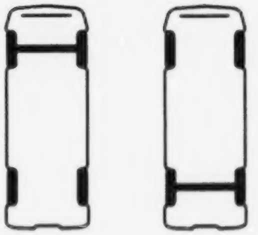
SOME OF THE VARIABLES IN DRIVETRAIN DESIGN ARE:



Location of the engine — The engine may be located in the front, middle, or back of the vehicle. Most engines are located in the front, however some two-passenger sports cars and some older models (such as the Volkswagen bug and the Pontiac Fiero) have engines in the middle or rear.

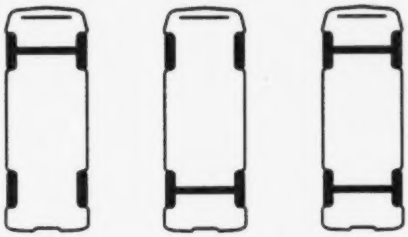


Alignment of the engine on the drive axles — The engine may be placed *North-South*, with the cylinders in a line with the front and rear of the vehicle, or it may be placed *East-West*, with its cylinders in a line with the drive axles. An East-West placement is called a ***transverse*** engine. A transverse engine allows a more compact engine compartment, leaving more room for the vehicle's passenger area. Most front-wheel drive vehicles have a transverse engine, while most rear-wheel and four-wheel drive vehicles have a North-South engine alignment.



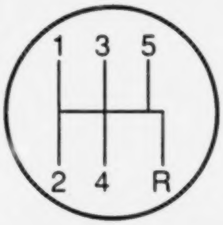
Location of the drive axles — Either the front or the rear axles may propel the vehicle. Front-wheel drive vehicles have no driveline and the functions of their transmission and differential are combined in a drivetrain component called a ***transaxle***.

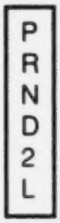
Front-wheel drive vehicles have several advantages. Engineers have found that it takes less energy to *pull* the car with front-wheel drive axles than it takes to *push* it from a rear axle. Because of the more compact design of its transaxle and the elimination of the driveline, front-wheel drive vehicles also realize a savings in both weight and space which makes them more economical to produce and to operate. Since its drive wheels are also used to steer, the automobile has a more responsive steering and having the engine weight over the drive axles gives the vehicle greater traction. Until recently, most vehicles were rear-wheel drive, but in the past few years, more front-wheel drive than rear-wheel drive vehicles have been produced.



Number of drive axles — Most automobiles are driven by only one set of drive axles, but four-wheel drive vehicles in which both front and rear axles are drive axles have become increasingly popular. Most four-wheel drive vehicles can operate as either a two-wheel or a four-wheel drive and are called *part-time* four-wheel drive vehicles. Vehicles which use both front and rear drive axles all the time are called *full-time* four-wheel drive vehicles.

Drivetrains on four-wheel drive vehicles contain *two* drivelines and *two* differentials (one for the front drive axles and one for the rear) and have an additional drivetrain component, a special gear assembly, called a ***transfer case***, which divides the power between the front and rear drive axles. Full-time four-wheel drive vehicles also have a third differential which is usually a part of the transfer case. A type of full-time four-wheel drive called an ***all-wheel drive*** has a special front-wheel drive transaxle design and eliminates the conventional transfer case. Because of the power of their extra drive axles, four-wheel drive vehicles are useful in off-road driving conditions.





Manual (standard) or automatic transmission — Adjusting the transmission's gears to allow for different driving needs can be done manually by the driver or automatically by an automatic transmission. In addition to having a different type of transmission, automobiles with automatic transmissions do not have a clutch as a part of their drivetrain; they have a drivetrain component called a ***torque converter*** which takes over the clutch's function and automatically connects and disconnects the engine and the transmission. Most drivers like the convenience of not having to depress a clutch pedal and shift gears. More vehicles with automatic transmissions are sold. It is possible for vehicles with manual transmissions to get better gas mileage, but only if the driver knows how to shift appropriately.

FUEL ECONOMY

To get a fuel economy advantage from a manual transmission, the driver must shift gears at the peak rpm for the gear in which the car is operating. It is the engine load, not the speed of the vehicle, which will tell him when this peak is reached. To determine peak rpm for the gears on a particular car, the driver should check the car's manual and then read the tachometer to monitor the rpm, shifting when the recommended rpm for the gear is reached. Remember: It is the depression of the gas pedal, not the gear the car is in, that controls fuel use.

COMMON DRIVETRAIN DESIGNS

	FRONT-WHEEL DRIVE front engine		REAR-WHEEL DRIVE front engine		FOUR-WHEEL DRIVE front engine	
Type of Transmission	Manual	Automatic	Manual	Automatic	Manual	Automatic
clutch	X		X		X	
torque converter		X		X		X
manual transmission			X			
automatic transmission				X		
manual transaxle	X				X	
automatic transaxle		X				X
transfer case					X	X
driveline			X	X	X X	X X
differential			X	X	X	X X
drive axles	X	X	X	X	X X	X X

X indicates number of this component present

MAKING A DIAGNOSTIC ROAD TEST

In order to diagnose many automotive problems, the service specialist must **road test** the vehicle to assist him in his evaluation. A road test is more than just a drive around the block. The service specialist must drive the car in a way that tests it for the automotive problems he suspects, allowing the road test to provide him with answers. A good road test helps the specialist get the *right* answers.

8 Steps in Making a Diagnostic Road Test:

1. **LISTEN** The first step in making a good road test is listening to the car's owner. What is he/she telling you about the behavior of the car? About the car's history?
2. **ASK QUESTIONS** After listening carefully, use your knowledge to ask questions that will help you in your diagnosis of the car's problems. What? How often? Under what conditions? Is the behavior constant or occasional? How long has the problem existed?
3. **OBSERVE** Let your observations give you important information about the car that will help you in your analysis. How old is the car? What is the mileage? Does the car appear to have ever been in an accident? Look for obvious clues such as tire wear or poor springs.
4. **CONSULT THE SERVICE MANUAL TROUBLESHOOTING GUIDE** Check the troubleshooting guide for the problem you suspect in the service manual for the car you are evaluating *before you take the car on the road*. See what type of road tests you should make on the vehicle and what symptoms you will be looking for. Do you need to drive at highway speeds? Will you be testing response during a sudden stop? Should you be listening for a noise? Watching for a certain behavior? Know beforehand what you will need to do and observe.

   ◆ WARNING ◆

   At this point you should ask yourself if the car is safe enough to be road tested. If not, check your diagnosis in other ways.

5. **MAKE THE ROAD TEST** Drive the vehicle, making the tests suggested by the troubleshooting guide. Check the owner's information by driving it under the conditions at which he noticed the problem—What does the "noise" sound like? What is the nature of the "vibration?" Be sure to use all normal safety precautions in driving an unfamiliar car: check the fluid levels and the brakes, buckle your seat belt, etc.

   CAUTION

   Driving in anything but a normal manner can make problems worse or create new ones.

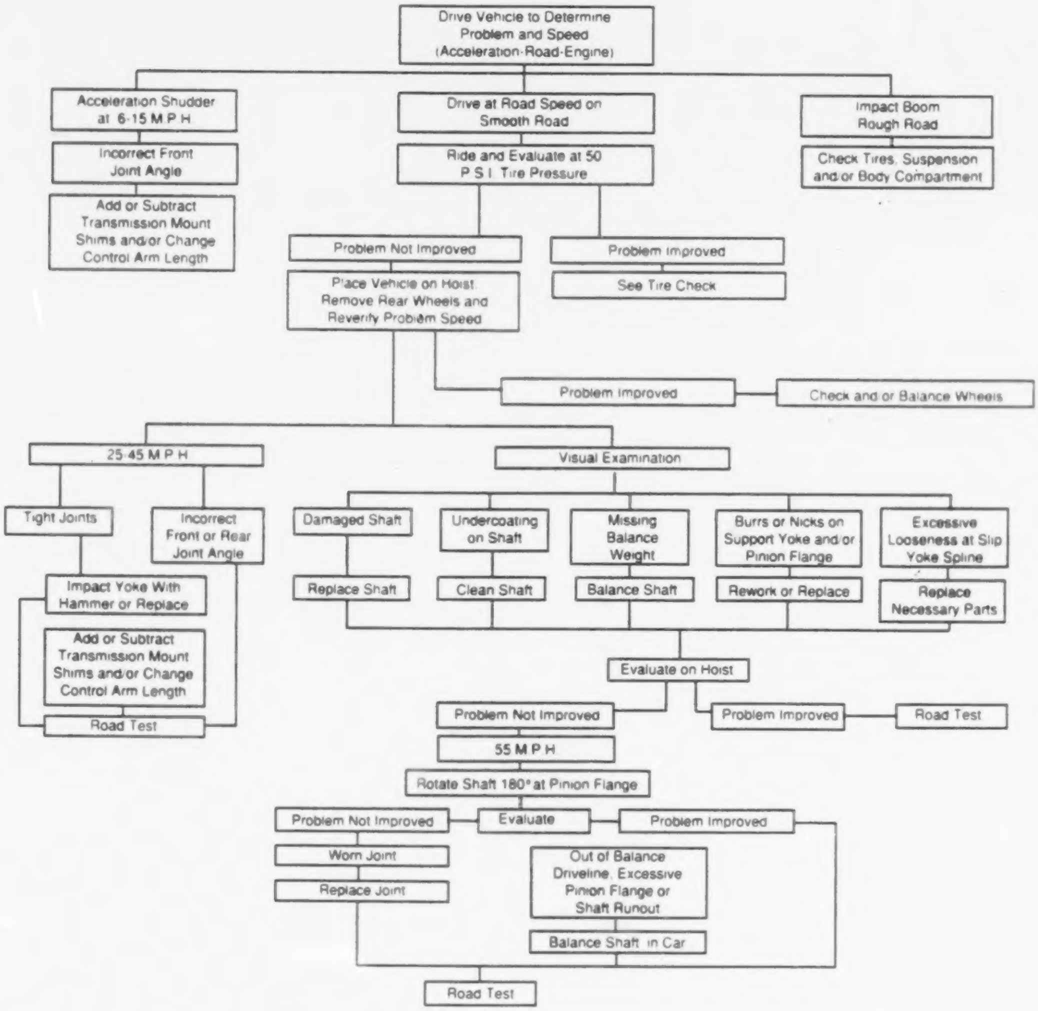
6. **NOTE YOUR RESULTS** If you make a number of checks, you may want to pull over and write down a few notes about the car's performance, or you could do this when you return to the shop.

7. **MAKE A PRELIMINARY DIAGNOSIS** Consider all the information you have gathered and make an initial diagnosis of the car's problems.

8. **CHECK YOUR DIAGNOSIS** You may need to check your diagnosis by making a visual examination or conducting other tests. Always make the simpler, less time-consuming tests first.

NOTE: Due to legal restrictions, students are frequently prohibited from making a road test. Students should get their instructor's permission before making a road test. It's also a good idea to road test vehicles over the same routes in case there is a breakdown.

DRIVELINE TROUBLESHOOTING GUIDE


Drive Vehicle to Determine Problem and Speed (Acceleration-Road-Engine)
Acceleration Shudder at 6-15 M.P.H.
Incorrect Front Joint Angle
Add or Subtract Transmission Mount Shims and/or Change Control Arm Length
Drive at Road Speed on Smooth Road
Ride and Evaluate at 50 P.S.I. Tire Pressure
Impact Boom Rough Road
Check Tires, Suspension and/or Body Compartment
Problem Not Improved
Problem Improved
See Tire Check
Place Vehicle on Hoist. Remove Rear Wheels and Reverify Problem Speed
Problem Improved
Check and/or Balance Wheels
25-45 M.P.H.
Tight Joints
Incorrect Front or Rear Joint Angle
Impact Yoke With Hammer or Replace
Add or Subtract Transmission Mount Shims and/or Change Control Arm Length
Road Test
Visual Examination
Damaged Shaft
Replace Shaft
Undercoating on Shaft
Clean Shaft
Missing Balance Weight
Balance Shaft
Burrs or Nicks on Support Yoke and/or Pinion Flange
Rework or Replace
Excessive Looseness at Slip Yoke Spline
Replace Necessary Parts
Evaluate on Hoist
Problem Not Improved
Problem Improved
Road Test
55 M.P.H.
Rotate Shaft 180° at Pinion Flange
Problem Not Improved
Evaluate
Problem Improved
Worn Joint
Replace Joint
Out of Balance Driveline, Excessive Pinion Flange or Shaft Runout
Balance Shaft in Car
Road Test

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DRIVELINE VIBRATION AND NOISE DIAGNOSTIC CHART

Causes that are more probable are listed first.

ROAD TEST ACTION	SYMPTOM	POSSIBLE CAUSE
Car shifted into gear	Noise	Loose U-joint Loose companion flange
Starting from a complete stop	Noise & Vibration	Incorrect driveline angle Improper phasing
Acceleration (Heavy)	Vibration	Dry/worn/damaged double Cardan joint Incorrect driveline angle
Shifting Gears	Noise	Worn transmission extension housing bushing Dry/worn/damaged U-joint Dry/worn/damaged slip joint
Driving at slow speed	Noise	Dry/worn/damaged U-joint
Driving at medium to high speeds	Noise	Improper phasing Incorrect driveline angle
Driving at high speeds	Noise	Dry/worn/damaged U-joint Dry/worn/damaged center support bearing (high whining) Incorrect driveline angle Improper phasing
	Vibration	Dry/worn/damaged U-joint Loose center support bearing bracket Improper phasing Loose flange bolt/yoke Missing shaft vibration damper Damaged/unbalanced driveshaft Incorrect driveline angle

ROAD TEST ACTION	SYMPTOM	POSSIBLE CAUSE
Driving at any speed	Noise or Vibration	Dry/worn/damaged U-joint Tight U-joint Dry/worn/damaged slip joint Damaged/unbalanced driveshaft Undercoating or dirt on driveshaft Missing driveshaft balance weights Dry/worn/damaged/loose center support bearing assembly Incorrect driveline angle Improper phasing Loose/damaged/missing flange or U-joint bolts Loose/damaged companion flange Excessive U-bolt torque Driveline or components assembled incorrectly

DRIVELINE DIAGNOSIS VISUAL INSPECTION CHECKLIST

- Tire damage or uneven tire wear

  NOTE: Tire damage or improperly balanced wheels are the most common sources of vehicle vibration problems. Some specialists routinely balance the wheels before seeking other sources of vibration.

- Dirt, mud, or undercoating on the driveline
- Obvious damage to any part—cracks, bends, breaks
- Missing parts—driveshaft weights, shaft vibration dampers, flange bolts, etc.
- Loose parts—flange bolts, center support bearings, etc.
- Leaking joints

As you manipulate joints on the driveline—

- Tight or dry U-joints

  NOTE: Notice red powder around trunnions—a sign of rust or wear.

- Looseness between U-joint yokes and spider
- Any more than a slight movement as you move a slip joint up and down or side to side
- A slip joint that has no movement at all

TORQUING A BOLT

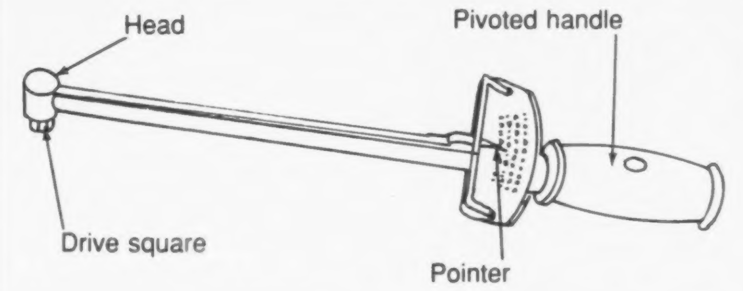
In many instances, it is very important to decide exactly *how tight* a bolt is tightened. If it is too tight, the bolt and nut may break; if it is too loose, the bolt could work out. Such a situation can not only cause damage to the vehicle, but creates a potentially life-threatening safety hazard.

In most cases a vehicle's service manual gives the tightening values, or ***torque specifications*** for each situation. Such specifications take into consideration such things as the size, composition, and hardness of the bolt, nut, or vehicle component, the amount and type of lubricant used, and the purpose of the connection. Standard bolt torque charts should be used only as a last resort.

For parts and assemblies employing several bolts, the manufacturers usually give a specific ***tightening sequence*** or order in which the bolts should be tightened. If the tightening sequence is not followed, warping, leaks, or damage can result.

Torque wrenches (Figure 1) are used to torque a bolt to specifications. Although there are several types of torque wrenches, all are designed to be used with a socket set and have a gauge which indicates the turning power (torque) which has been applied to the bolt.

FIGURE 1



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Guidelines for torquing a bolt:

- Make sure the bolt threads are clean and lightly oiled with a high temperature lubricant.

- Use the manufacturer's torque specifications and tightening sequence if available.

  NOTE: If the manufacturer's torque specifications are not available, use a standard bolt torque chart. If the manufacturer's tightening sequence is not available, use a general crisscross pattern, starting in the middle, working to the outside.

- Do not allow the wrench to touch anything other than the bolt itself while you are applying pressure. An incorrect reading could result.

- Pull the wrench toward you at a right angle to the bolt. Avoid pulling up or pressing down; an incorrect reading can result.

- Apply steady pulling pressure to the wrench. Jerky movements can result in an incorrect torque reading.

- If the bolt sticks, loosen it and begin pulling again steadily until the correct torque is reached.

- Read the torque wrench gauge by looking straight down at it. Looking at it from an angle can give an incorrect reading.

- If you are not satisfied that you have torqued the bolt correctly, retorque.

- Some assemblies require that the bolts be retorqued after operating the vehicle—especially when bolts are installed in an area sensitive to heat. Be alert to this possibility and follow the directions given.

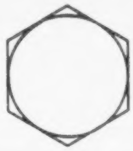
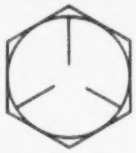
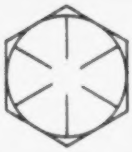
- Follow these five steps:

  1. Tighten the bolt snugly with a regular wrench.
  2. Use the torque wrench to tighten to one-half the recommended torque.
  3. Tighten it to three-fourths torque.
  4. Tighten to full torque.
  5. Retighten each bolt to full torque, making sure you have not missed any.

BOLT TORQUE

Inch Sizes

SAE Classification. Markings found on top of bolt head indicate grade (strength) of the bolt. Increasing numbers represent increasing strength.

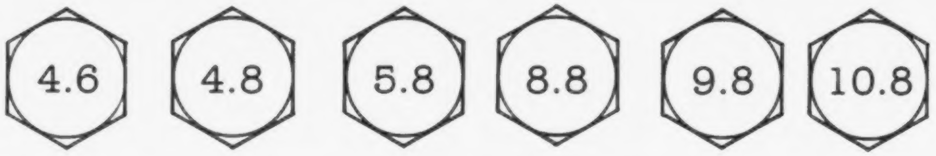
Grade 2	Grade 5	Grade 8
		

	GRADE 5		GRADE 8	
Size	In. Lbs. Ft. Lbs.	newton metres	In. Lbs. Ft. Lbs.	newton metres
1/4-20	95 In. Lbs.	10.7	125 In. Lbs.	14.1
1/4-28	95 In. Lbs.	10.7	150 In. Lbs.	16.9
5/16-18	200 In. Lbs.	22.6	270 In. Lbs.	31.2
5/16-24	20 Ft. Lbs.	27.1	25 Ft. Lbs.	33.9
3/8-16	30 Ft. Lbs.	40.7	40 Ft. Lbs.	54.2
3/8-24	35 Ft. Lbs.	47.5	45 Ft. Lbs.	61.0
7/16-14	50 Ft. Lbs.	67.8	65 Ft. Lbs.	88.1
7/16-20	55 Ft. Lbs.	74.6	70 Ft. Lbs.	95.0
1/2-13	75 Ft. Lbs.	101.7	100 Ft. Lbs.	135.6
1/2-20	85 Ft. Lbs.	115.2	110 Ft. Lbs.	149.1
9/16-12	105 Ft. Lbs.	142.4	135 Ft. Lbs.	183.0
9/16-18	150 Ft. Lbs.	156.0	150 Ft. Lbs.	203.4
5/8-11	115 Ft. Lbs.	203.4	195 Ft. Lbs.	264.4
5/8-18	160 Ft. Lbs.	217.0	210 Ft. Lbs.	284.7
3/4-16	175 Ft. Lbs.	237.3	225 Ft. Lbs.	305.1

Grade 2 bolts are not normally used in automotive applications.

Metric Sizes

SAE Classification. Identification class numbers indicate bolt strength. Increasing numbers represent increasing strength.

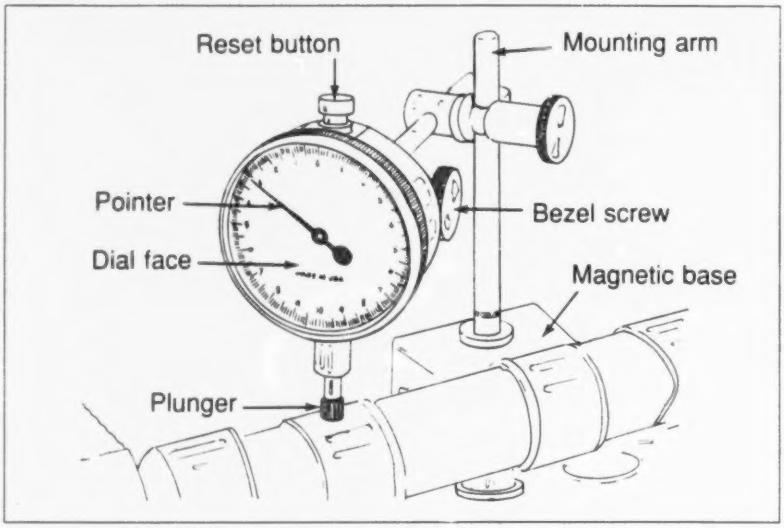


		6 & 6.3	8	10	12	14	16	20
NUTS AND ALL METALS BOLTS	N-m	0.4	0.8	1.4	2.2	3.0	4.2	7.0
	In. Lbs.	4.0	7.0	12	18	25	35	57

USING A DIAL INDICATOR

A ***dial indicator*** is a precision measuring instrument that measures movement in thousandths of an inch. (Figure 1) It can be of help in a number of important ways. For example, moving a dial indicator over the surface of a part is useful for determining if the surface is even. A dial indicator measurement made on an axle or driveshaft can tell you if the circumference is perfectly round. If you use an indicator to measure the face of a gear or flange, you can discover if the surface is worn or warped. A dial indicator measurement of the movement between two interlocking parts such as gears can tell you how closely the two parts fit. In circumstances where precision is important to proper functioning, dial indicator measurements are invaluable to proper diagnosis and adjustment.

FIGURE 1



The face of a dial indicator is calibrated in either thousandths of an inch or in millimeters. The gauge starts at zero and the measurements on either side of zero indicate either a plus or minus movement—the plunger is either moving in or it is moving out. The range of the indicator—the distance the plunger on the indicator is able to move in and out—can vary. It can usually move anywhere from .2 to 1.0 inch.

Many dial indicators come with a variety of holding attachments (mounting arms and bases, magnets, swivels, and adapters) that aid in attaching it firmly to a nearby immovable surface so an accurate measurement can be made.

Steps in Making a Typical Dial Indicator Measurement

Position

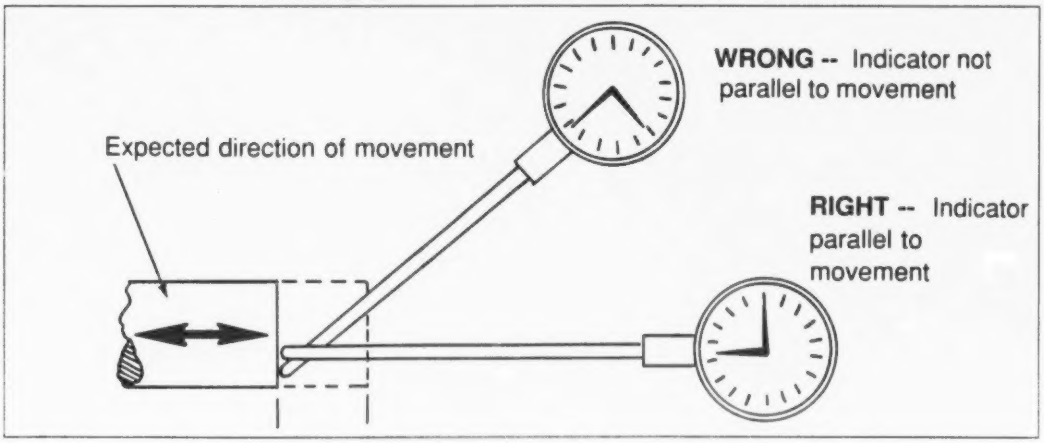
1. Install the appropriate holding attachment firmly to a nearby surface that will not be moving during the test.

2. Attach the dial indicator loosely in the holding attachment.

3. Position the plunger on the indicator so it is parallel to the movement you want to measure. (Figure 2)

   NOTE: The movement you want to measure should either move directly toward or away from the dial indicator. Make sure when there is motion, the plunger is situated so it will move in or out with it.

FIGURE 2


WRONG -- Indicator not parallel to movement
Expected direction of movement
RIGHT -- Indicator parallel to movement

Preload

4. Push the indicator plunger firmly against the part, depressing the plunger so that the pointer on the indicator dial moves about ¾ of the way around the dial.

5. Keep pressing the plunger against the part while you tighten the bezel clamp screw, securing the dial indicator firmly in place against the part.

   NOTE: Movement of the part in either direction should now cause the dial pointer to move.

Set

6. Set the pointer on the dial indicator to zero.

7. Watch the pointer as you move the part back and forth or rotate the part—when the part moves away from the dial indicator, the pointer will move to the left of zero. When the part moves toward the dial indicator, the pointer will move to the right.

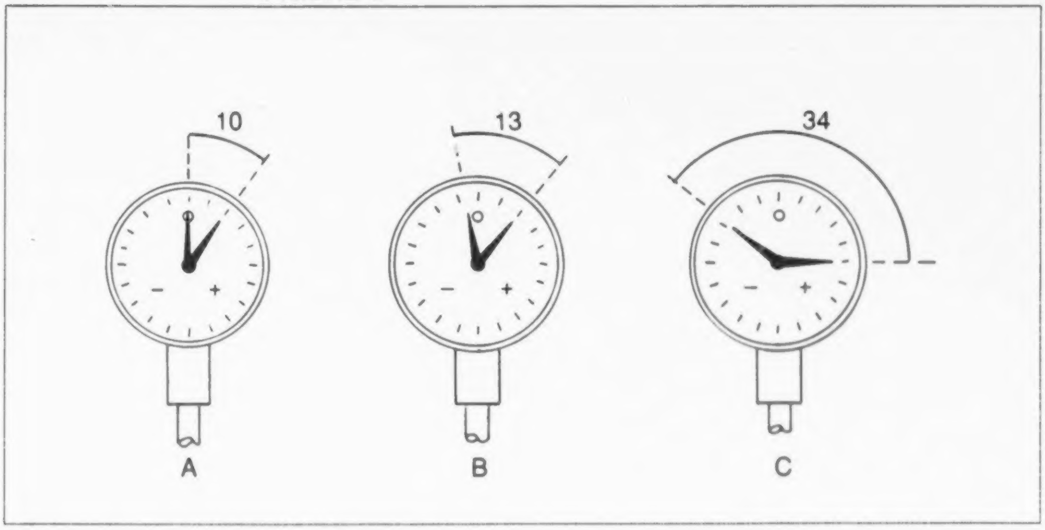
Measure

8. Move the part back and forth one time, or rotate it one time—whichever movement is appropriate for the measurement you need. Watch the pointer on the dial indicator and note both the highest and the lowest measurement.

9. Subtract the lowest reading from the highest reading to figure the correct dial indicator measurement. (Figure 3)

EXAMPLES:	**Highest Reading**	**Minus**	**Lowest Reading**		**Indicator Reading**
A.	(+10)	–	(0)	=	+10
B.	(+10)	–	(–3)	=	+13
C.	(+20)	–	(–14)	=	+34

FIGURE 3



NOTE: If you set the pointer at zero and during the test the pointer moved 10 mm. to the positive side of zero at its highest point and at its lowest point, it moved back to 3 mm. on the negative side of zero, the pointer moved 13 mm. altogether.

Check

10. Repeat the measurement procedure to assure yourself of its accuracy.

11. Compare the dial indicator reading for your test to the manufacturer's specifications for that measurement in the vehicle's service manual.

ALTERNATE METHOD OF MEASUREMENT

1. Position and Preload the dial indicator as described in 1 - 7.

2. Move the part back and forth one time, or rotate it one time—whichever movement is appropriate for the measurement you need.

3. Watch the pointer on the dial indicator and note the lowest measurement reached by the indicator pointer.

4. Mark the part at that point with an awl or permanent marker.

5. With the plunger at that point, re-set the pointer on the dial indicator to zero.

6. Check your identification of the low point by moving the part back and forth, or rotating it again to make sure the pointer does not move to the left of zero. (The plunger should not be moving away from the dial indicator since you have already identified the position at which it moves the farthest.)

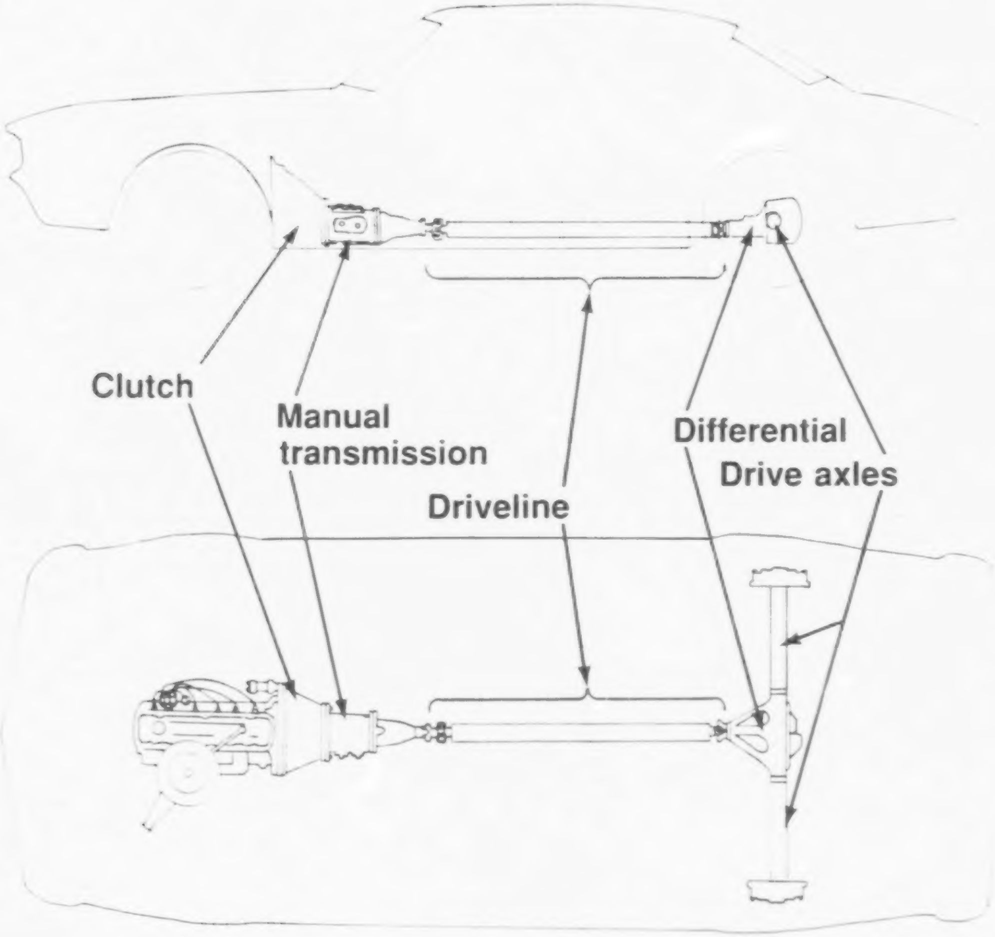
   NOTE: If the pointer **does** move to the left, it is the position where that movement occurs, rather than the position at which you zeroed the indicator, that is the low point.

7. Correct the low point position by remarking the part and resetting the pointer to zero.

8. Move the part back and forth one time or rotate it one time—whichever movement is appropriate for the measurement you need.

9. Watch the pointer on the dial indicator and note the highest measurement—this will be the **total** measurement.

Rear-Wheel Drivetrain


Clutch
Manual transmission
Driveline
Differential
Drive axles

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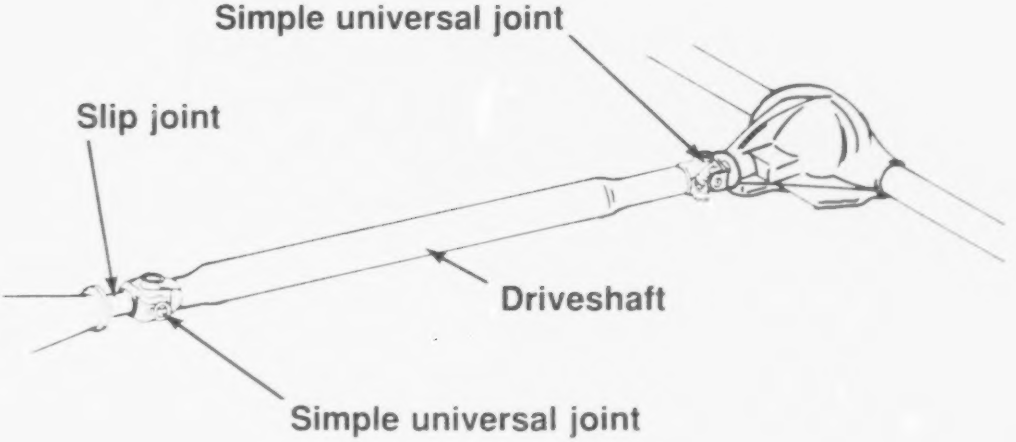
Components of a Driveline


Simple universal joint
Slip joint
Driveshaft
Simple universal joint

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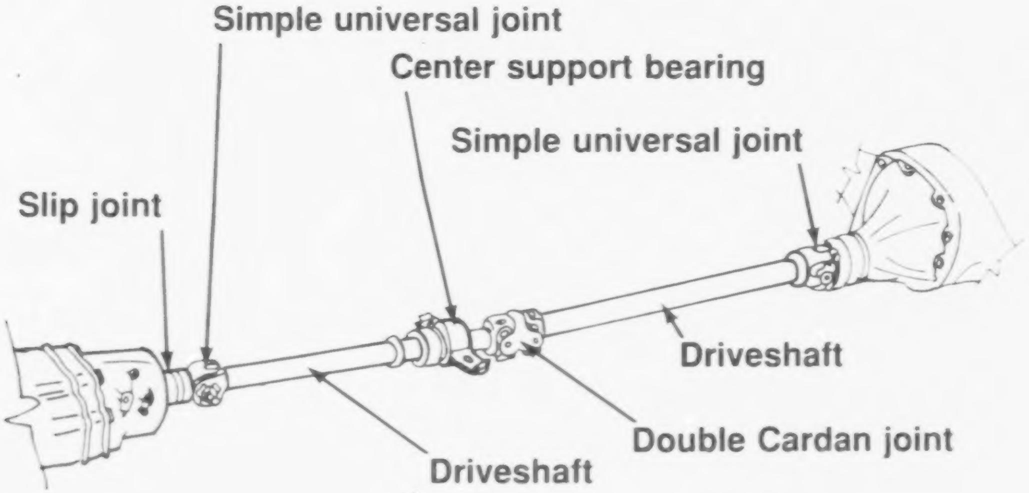
Simple universal joint
Center support bearing
Simple universal joint
Slip joint
Driveshaft
Double Cardan joint
Driveshaft

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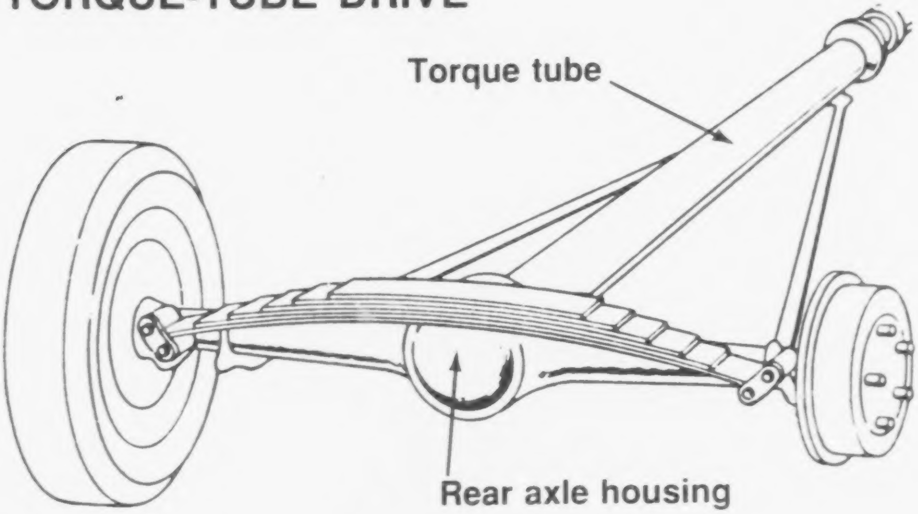
Types of Drivelines

TORQUE-TUBE DRIVE


Torque tube
Rear axle housing

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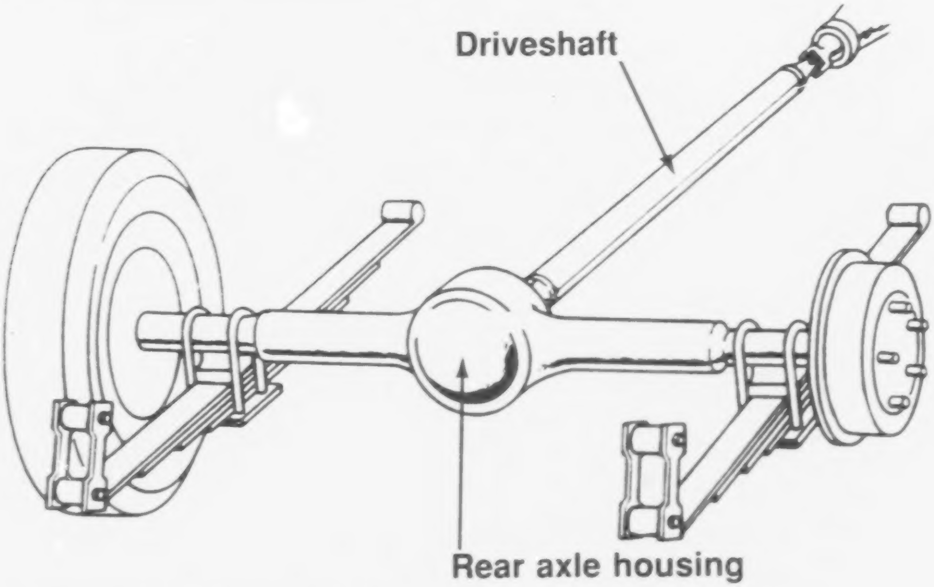
HOTCHKISS DRIVE


Driveshaft
Rear axle housing

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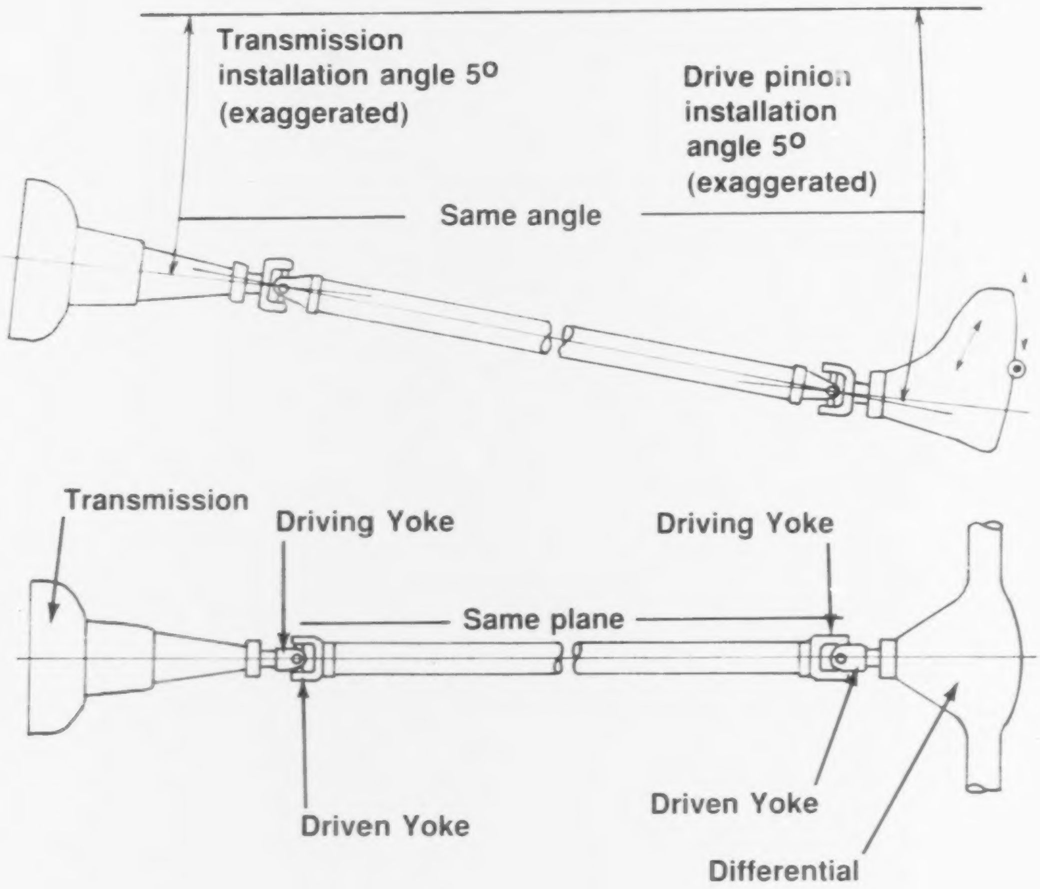
Phasing the Universal Joints


Transmission installation angle 5°
(exaggerated)
Drive pinion installation angle 5°
(exaggerated)
Same angle
Transmission
Driving Yoke
Driving Yoke
Same plane
Driven Yoke
Driven Yoke
Differential

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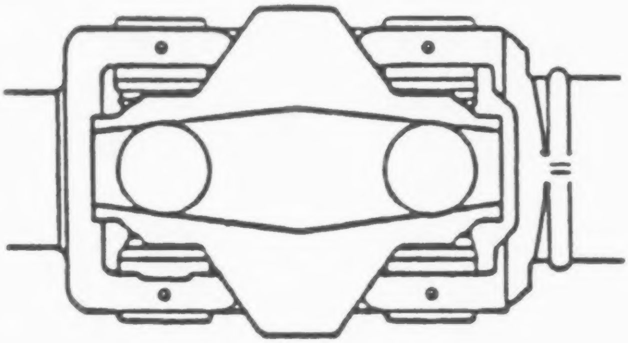
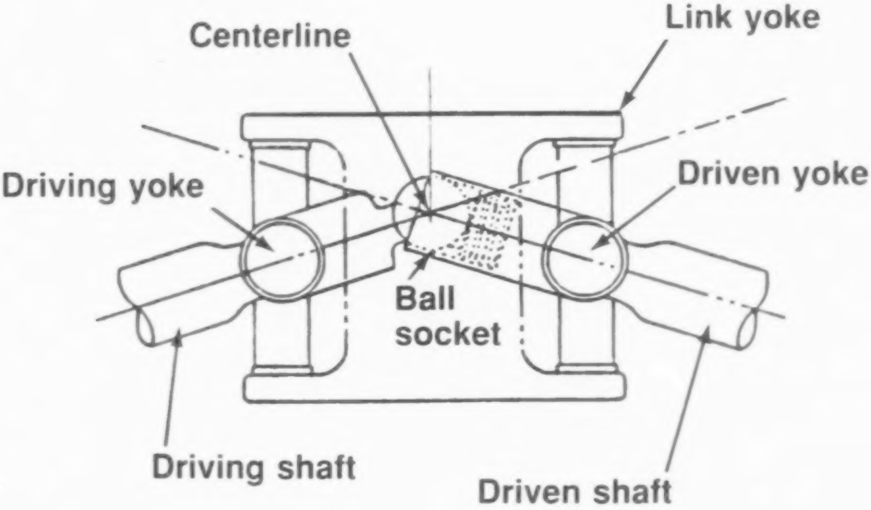
Constant Velocity Universal Joints




Centerline
Link yoke
Driving yoke
Driven yoke
Ball socket
Driving shaft
Driven shaft

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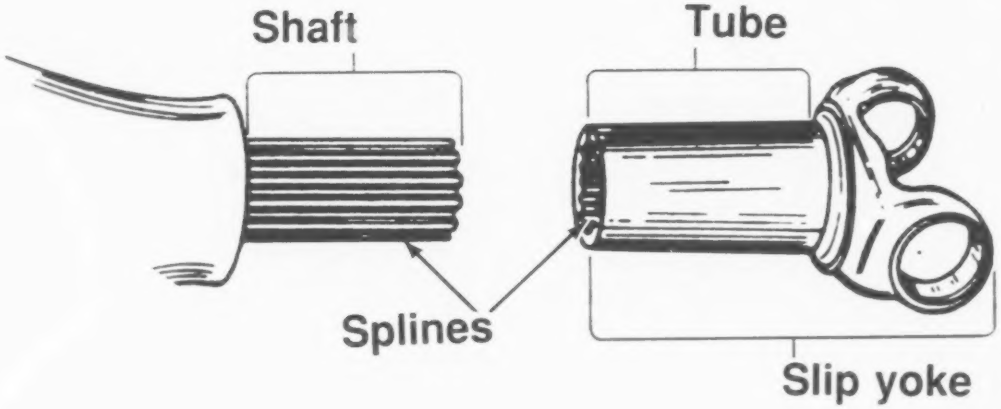
Slip Joint


Shaft
Tube
Splines
Slip yoke

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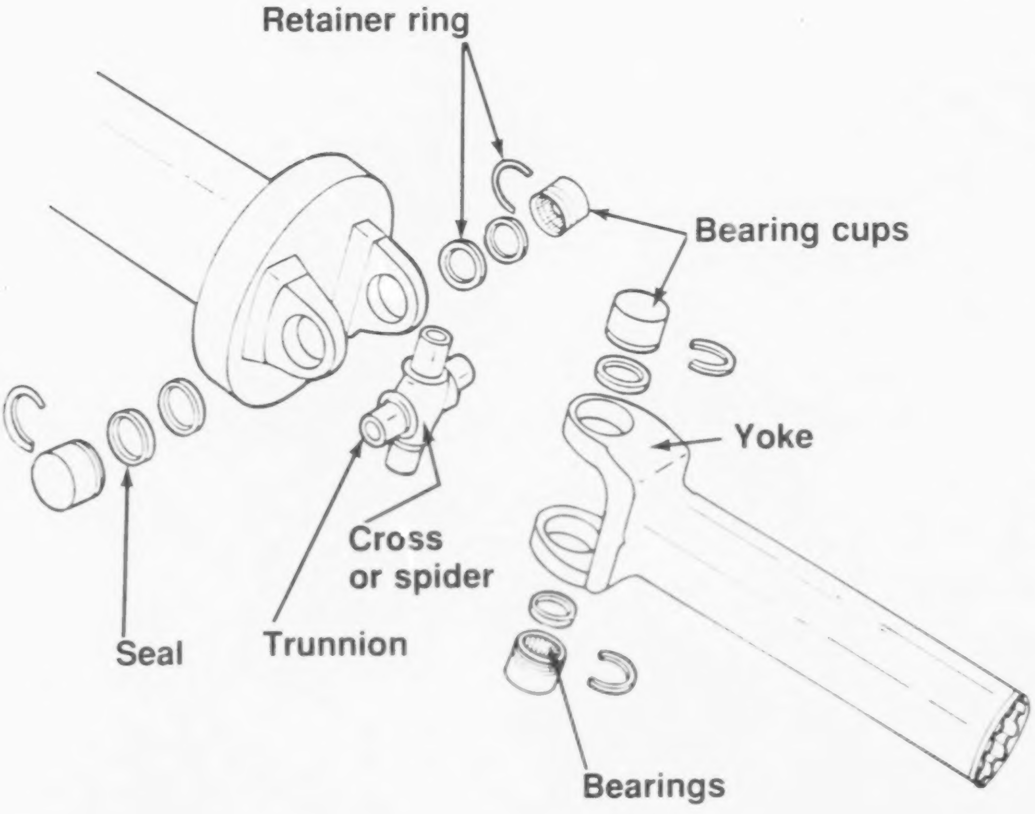
Simple Universal Joint


Retainer ring
Bearing cups
Yoke
Cross
or spider
Seal
Trunnion
Bearings

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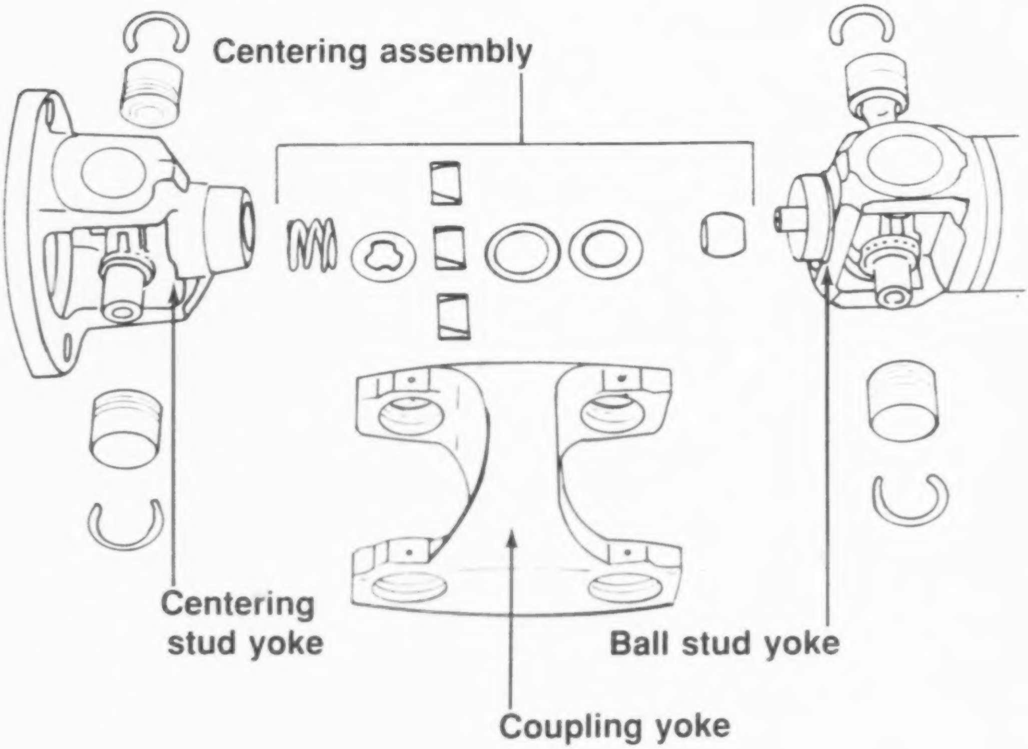
Double Cardan Joint


Centering assembly
Centering stud yoke
Ball stud yoke
Coupling yoke

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ASSIGNMENT SHEET 1 — SERVICE DRIVELINES

I

NAME ______________________ SCORE ______

OBJECTIVE 10 **Diagnose driveline noise and performance problems.**

INTRODUCTION

Noise and vibration, the most common symptoms of driveline problems, are also symptoms of a number of other common automotive problems—wheel and tire imbalance, problems with the suspension and steering, muffler, clutch, transmission, etc. Making two types of tests, a road test and a visual inspection, will diagnose most driveline problems. These diagnostic evaluations are made without removing the driveline from the vehicle. Because the driveline is a carefully balanced unit and subject to damage during the process of removal, removing the driveline to manipulate and inspect its components is made only as a last resort.

Road Test

Before making the road test, refer to the vehicle's service manual to provide you with guidelines on how to drive the vehicle to test it for the problems you suspect. Only if you consult the manual in advance can you be sure to get the answers you need. Supplement 3, ***Making a Diagnostic Road Test***, Supplement 4, ***Driveline Troubleshooting Guide***, and Supplement 5, ***Driveline Vibration and Noise Diagnostic Chart***, will help you make a good road test for driveline problems.

Visual Inspection

Even if you road test a vehicle which is noisy and vibrates, it can be very difficult to pinpoint the source of the problem; at most, the road test can identify the *likely* source of the trouble. Visual inspection of the driveline area can identify and confirm the source of the problem more exactly. Raise the vehicle so the driveline area is exposed, and use the ***Driveline Visual Inspection Checklist*** in Supplement 6 to assist in making a diagnosis.

DIRECTIONS

Use Student Supplements 3, 4, 5, and 6 to help you select the answer for each that is *most* correct. Write the correct letter in the blank.

______1. Your road test reveals that the vehicle shudders when accelerating at a low speed. When you make your visual check, you check for the probable cause of this response by checking:

A. Universal joint angles
B. Center support bearing
C. Slip joint
D. Burrs on the companion flange

______2. During the road test you notice a high whining noise from the driveline area. What is the probable cause?

A. Bad U-joint
B. Undercoating on the driveline
C. Bad center support bearing
D. Bad slip joint

______3. After your road test shows vehicle vibration at 40 mph, you hoist the vehicle, remove the rear wheels, and run the engine at 40 mph. The vibration improves—what is the probable cause?

A. Incorrect universal joint angles
B. Improperly balanced wheels
C. Unbalanced driveshaft
D. Unbalanced center support bearing

______4. The last step in diagnosing driveline problems is always:

A. Removing the driveline
B. Road test to see if the symptoms are improved
C. Replacing the defective component
D. Checking the vehicle's service manual

______5. A farmer brings in his truck and complains of vibration when driving at moderate speeds down dirt roads. Which of the following will **least likely** to be a part of your diagnostic tests?

A. Questioning the farmer about the vehicle's behavior
B. Consulting the vehicle's service manual
C. Driving at moderate speed down a four-lane highway
D. Making a visual inspection of the driveline

______6. You do not check the vehicle's service manual and you cannot diagnose the vehicle's vibration problem through your road test and visual check. What could the service manual tell you that you don't already know?

A. The vehicle has a shaft vibration damper that is now missing
B. The vehicle should have balance weights that are not there now
C. The vehicle has simple universal joints and it should have double Cardan joints—someone installed the wrong parts
D. All of the above

______7. A flange bolt can cause vibration if it is:

- A. Too loose
- B. Too tight
- C. Both A and B
- D. Neither A nor B

______8. Red powder around a U-joint is a sign that:

- A. The joint is rusted
- B. There is dirt clogging the driveline
- C. The joint is lubricated by a special powder
- D. The joint is too tight

______9. Which of the following should be done **first** when diagnosing a driveline problem?

- A. Check the vehicle's service manual
- B. Listen to the vehicle's owner tell you about the problem
- C. Make a diagnostic road test
- D. Make a visual inspection of the driveline

_____10. Which of the following is usually **not** a part of most driveline diagnosis?

- A. Diagnostic road test
- B. Visual inspection of the driveline
- C. Questioning the vehicle's owner
- D. Removing the driveline to check the components

SERVICE DRIVELINES

ASSIGNMENT SHEET 1

1. A
2. C
3. B
4. B
5. C
6. D
7. C
8. A
9. B
10. D

JOB SHEET 1

SERVICE DRIVELINES

OBJECTIVE 11A

Measure and adjust universal joint angles.

INTRODUCTION

Driveline vibration is often caused by incorrect universal joint angles on the driveline. The best angle for the operation of each universal joint varies with the vehicle and is given in the vehicle's service manual; angles should be within the manufacturer's specifications. Measuring and adjusting universal joint angles is done while the driveline is still on the vehicle, and for this reason, it is one of the first checks that should be made. If the driveline is later removed for any reason, the universal joint angle should be checked again after the driveline is reinstalled.

What Causes U-Joint Operating Angles to Change?

- Worn suspension
- Revisions in driveline components
- Stretching or shortening of the chassis
- Worn transmission mounts
- Damage to the driveline

The correct procedure for adjusting universal joint angles varies—consult the appropriate vehicle service manual. The procedure given is typical.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 7, ***Torquing a Bolt***
- Eye protection
- Hoist which allows the entire driveline to be exposed without obstruction
- Ruler
- Shop light
- Inclinometer
- Pencil and paper
- Transmission jack
- Shop cloths
- Combination wrench
- Torque wrench
- Shims

NOTE: Information on correct shim widths for desired angle correction can be found in vehicle service manual.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

USING SERVICE MANUALS

No textbook can provide detailed instructions to complete every type of automotive service and repair on every type of vehicle. Learning to use appropriate automotive service manuals to guide their work is one of the most important tasks technicians can learn. Correct and consistent use of service manuals is the hallmark of an expert technician.

The student should always use the appropriate service manual to complete every job sheet. Although the procedures contained in the job sheets in this manual provide sound guidelines for the procedure indicated, ***no job sheet procedure will be exactly correct for every vehicle.***. Some job sheets do not even give a general procedure to follow because there is no "general" procedure—the components or parts involved are too different from one vehicle to the next.

When the text refers the student to the service manual, it is asking the student to use the most accurate book to do the job—the appropriate service manual.

PROCEDURE

Measure universal joint angles

1. Make sure the vehicle is at curb weight, and is resting on a level surface.

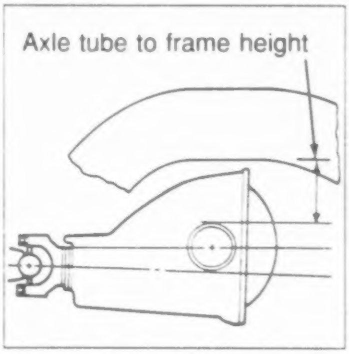
   NOTE: Curb weight is the weight of an automobile with standard equipment including a spare tire and a full tank of gas.

2. Use a ruler to measure the rear trim height against service manual specification. (Figure 1)

   NOTE: Rear trim height is measured from the top of the rear axle to the bottom of the frame.

3. If the height is greater than specification, lower the vehicle and add weight until specification is reached.

FIGURE 1



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4. Pull the vehicle onto the hoist, shift into neutral and release the emergency brake so that the driveline will turn freely.

5. Raise the vehicle and support safely.

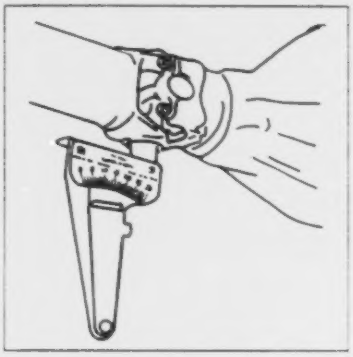
6. Rotate the rear universal joint until the bearing cup is positioned straight up and down.

7. Use a shop cloth to clean the bearing cup and then position an inclinometer on the cup. (Figure 2)

8. Center the bubble in the sight and record the measurement.

9. Rotate the driveline 90° to the next bearing cup and repeat the measurement procedure.

FIGURE 2



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10. Subtract the smaller measurement from the larger and compare the measurement to the service manual specification.

11. Move the inclinometer to the front universal joint and repeat the procedure.

    NOTE: Incorrect universal joint angles can be a result of weak or broken rear springs. Rear springs should be checked if a major angle adjustment is indicated.

PROCEDURE

Adjust front universal joint angle

NOTE: If the front angle reading is low or negative, no correction is needed.

1. Place a transmission jack under the transmission extension housing.

2. Remove the transmission mount bolts with a wrench.

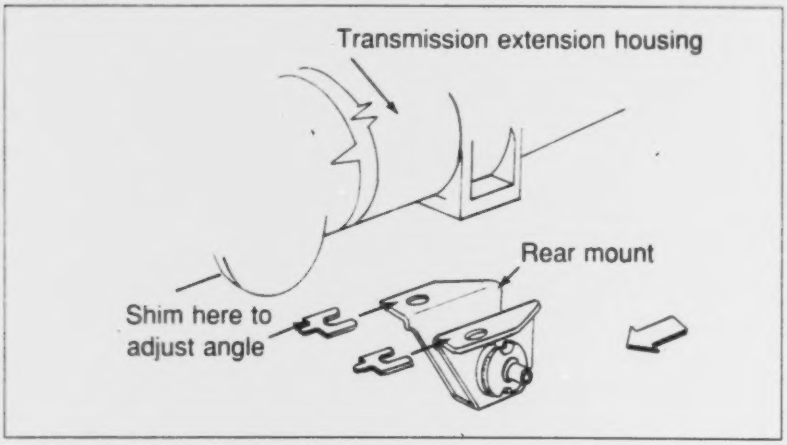
    NOTE: Inspect the transmission mount for damage or wear when removing the bolts. Making an angle adjustment may require a new transmission mount.

3. Raise the transmission extension housing with the transmission jack.

4. Install shims. (Figure 3)

   NOTE: ***Shims*** are small parts made of flat pieces of sheet metal used to adjust the fit between parts or components. Shims come in sets in which each shim is a different precision-machined thickness. This allows the technician to select a shim which will make an exact adjustment.

FIGURE 3



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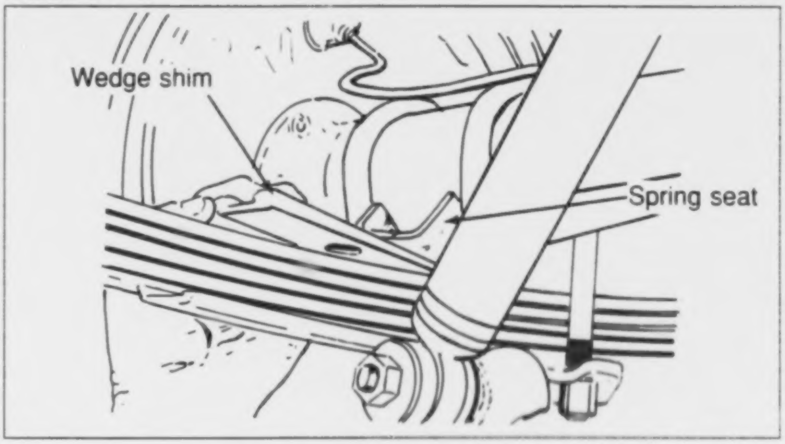
5. Lower the transmission with the transmission jack.
6. Replace the transmission mount bolts and use Supplement 7, "Torquing a Bolt," to tighten them to proper torque specifications.
7. Measure the universal joint angle again.
8. Repeat this procedure and add or remove shims until the correct angle is reached.
9. Adjust the rear universal joint angle if needed.
10. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Adjust rear universal joint angle

1. Loosen the nuts that hold the rear leaf springs to the axle housing.
2. Without removing the nuts, place wedge shims between the springs and the spring seat. (Figure 4)

FIGURE 4



Adapted with permission of Chrysler Corporation.

NOTE: Place the thick end of the shim toward the *front* of the vehicle to *reduce* the angle; place the thick end towards the *rear* of the vehicle to *increase* the angle.

3. Align the wedge hole with the spring seat.
4. Tighten the nuts to proper torque specifications.
5. Measure the universal joint angle again.
6. Repeat this procedure and add or remove shims until the correct angle is reached.
7. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB
SHEET 2

SERVICE DRIVELINES

OBJECTIVE 11B

Check driveshaft runout and adjust minor driveshaft imbalance.

INTRODUCTION

A driveshaft that is bent or damaged will cause driveline vibration. Checking a driveshaft's runout is checking its straightness. ***Runout*** is the distance the surface or edge of a rotating part moves in or out during rotation. The method given here is for checking driveshaft runout with a dial indicator. Runout can also be checked with an electronic wheel balancer. Checking driveshaft runout is performed while the driveline is still on the vehicle, and for this reason, it is one of the first checks that should be made.

If the runout check shows a minor driveshaft imbalance, it can be corrected using hose clamps. If the imbalance cannot be corrected using hose clamps, the driveshaft will have to be repaired or replaced.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, ***Using a Dial Indicator***
- Supplement 7, ***Torquing a Bolt***
- Eye protection
- Hoist which allows the entire driveline to be exposed without obstruction
- Hoist stand or other movable support
- Shop light
- Shop cloths
- Approved cleaning solvent
- Dial indicator
- Pencil and paper
- Combination wrench
- Torque wrench
- Crayon or permanent marker
- 2 to 4 worm screw hose clamps
- Screwdriver

NOTE: You will need the help of an assistant to help hold the heavy driveshaft when disconnecting and rotating the driveline in an effort to correct runout. An assistant's help is also needed in correcting minor driveshaft imbalance.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be raised and supported safely. The transmission should be in neutral, and the emergency brake should be disengaged. (Job Sheet 1)

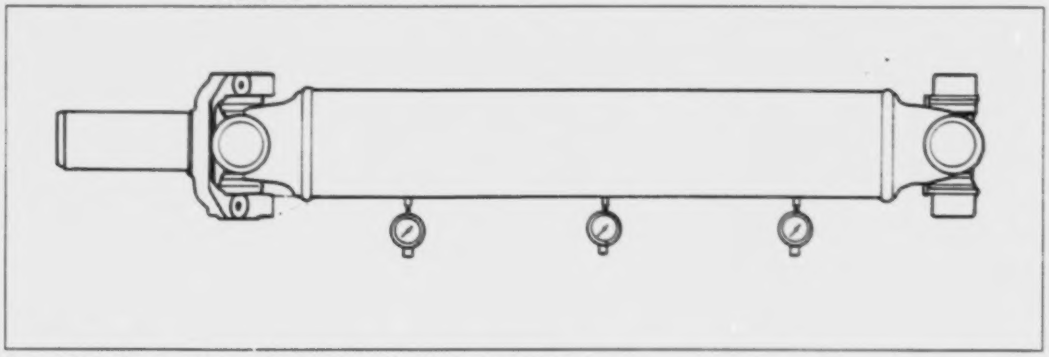
PROCEDURE

Measure driveshaft runout

1. Mount the dial indicator on a hoist stand or other movable support.
2. Use an approved cleaning solvent and shop cloth to clean the driveshaft surface so the dial indicator can move freely.

   NOTE: Dial indicator readings should be taken near the middle of each third of the driveshaft. (Figure 1) Be sure to avoid driveshaft balance weights and other normal shaft surface variations.

FIGURE 1



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3. Use Supplement 8, "Using a Dial Indicator," to help you position and set the dial indicator correctly.
4. Position the dial indicator near middle of the driveshaft with the indicator plunger at a right angle to the driveshaft.
5. Have your instructor check the position of the dial indicator.
6. Turn a rear wheel to rotate the driveline one complete turn.

   ◆ WARNING ◆

   Keep long hair and loose clothing away from rotating driveline. Serious injury can occur if they become entangled with driveline components.

7. Note the indicator reading.
8. Reposition the dial indicator near the middle of the front third of the driveshaft and note runout reading.

9. Repeat the measurement with the indicator positioned near the middle of the rear third of the shaft.

10. If any runout reading exceeds the manufacturer's specifications, use a combination wrench to disconnect the driveline at the companion flange and rotate the driveshaft 180°.

◆ WARNING ◆

Drivelines are extremely heavy. Get an assistant to help hold the driveline before disconnecting and rotating it.

CAUTION

Do not allow the driveline to hang from the front universal joint or allow any universal joints to bend to an extreme angle. Damage will result.

11. Reconnect the driveline, using Supplement 7, "Torquing a Bolt," to help you tighten the bolts to required torque.

12. Recheck driveshaft runout in all three positions.

13. If driveshaft runout is still over specifications at any position, use the following procedure to try to correct the imbalance.

PROCEDURE

Adjust minor driveshaft imbalance

1. Have your assistant start the engine, put the vehicle in gear, and hold a steady speed of about 40 mph.

◆ WARNING ◆

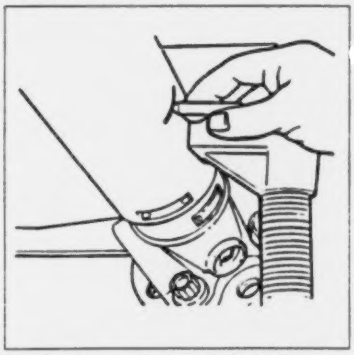
Keep long hair and loose clothing away from rotating driveline. Serious injury can occur if they become entangled with driveline components.

2. Holding a crayon at the point on the driveshaft nearest the rear universal joint, rest your arm on the jack stand and very slowly move the crayon toward the rotating driveshaft. (Figure 2)

◆ WARNING ◆

Use extreme caution when performing this procedure.

FIGURE 2



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3. Withdraw the crayon the moment it touches the driveshaft.

4. Turn off the engine and allow the driveline to stop spinning.

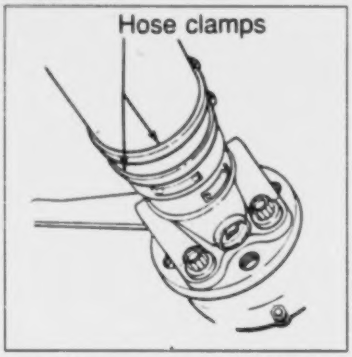
5. Place two worm screw hose clamps around the driveshaft at the rearmost point on the driveshaft. (Figure 3)

6. Position both screw heads together on the side of the driveshaft directly opposite the heavy spot.

7. Tighten the screws with a screwdriver.

8. Have your assistant start the engine, place the vehicle in gear, and maintain the speed at which the vibration or noise occurred on the road test.

FIGURE 3



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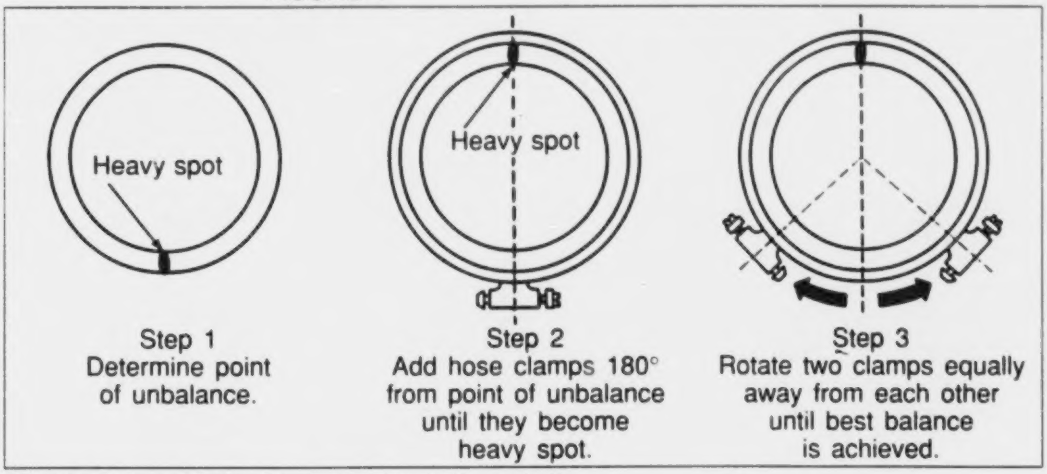
9. If driveline vibration is reduced, turn off the engine and allow the driveline to stop spinning.

10. Loosen the clamps and move both screws an equal distance away from the point opposite the heavy spot. (Figure 4)

FIGURE 4



Step 1
Determine point
of unbalance.

Step 2
Add hose clamps 180°
from point of unbalance
until they become
heavy spot.

Step 3
Rotate two clamps equally
away from each other
until best balance
is achieved.

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11. Start the engine and repeat the check for vibration.

12. Continue to move the clamps apart equal distances until the point of lowest vibration is found.

13. If the vibration level is still unsatisfactory, repeat the procedure, placing hose clamps at the front of the driveshaft.

14. Reduce vibration to the lowest level possible and road test the vehicle.

15. If vibration is not satisfactory at this point, repair or replace the driveshaft.

16. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 3 SERVICE DRIVELINES

OBJECTIVE 11C

Remove and replace the driveline.

NOTE: After a part or component is removed from its normal position, it can be cleaned, inspected, and reinstalled, or it can be replaced with a new replacement part or component. Throughout this book, the word "replace" is used to indicate the installation of *either* the old part or a new part.

INTRODUCTION

If correcting driveline angles and runout does not solve noise and vibration problems, other driveline components will have to be checked. The driveline must removed *as a single unit* before individual components can be thoroughly inspected, serviced, or replaced. Components on some drivelines cannot be replaced. If any part is faulty, the entire driveline must be replaced.

Remember that driveline joints can bend only a few degrees without damage. The driveline is also extremely heavy, so you will need the help of an assistant to complete this job sheet. The following procedure is typical for most single-driveshaft drivelines, however it is always a good policy to check the service manual for the vehicle you are servicing to review the correct procedure for that vehicle.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 3, ***Making a Diagnostic Road Test***
- Supplement 4, ***Driveline Troubleshooting Guide***
- Supplement 5, ***Driveline Vibration and Noise Diagnostic Chart***
- Supplement 7, ***Torquing a Bolt***
- Eye protection
- Hoist
- Hoist stands
- Shop light
- Combination wrench
- Torque wrench
- Drain pan
- Shop cloth, rag, or plastic plug
- Masking tape
- Permanent marker or sharp awl
- Transmission lubricant or chassis grease

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be raised and supported safely. The transmission should be in neutral, and the emergency brake should be disengaged.

PROCEDURE

Remove the driveline

1. Place a drain pan under the transmission extension housing/slip joint area to keep the transmission lubricant from leaking onto the shop floor.

2. Use a permanent marker or sharp awl to mark the relationships of all driveline components with matchmarks.

MATCHMARKS

Drivelines are balanced at the factory as a complete unit. If they are not reassembled with each component and part in the original relationship to all others, vibration and noise will result. The importance of correct reassembly in phasing the universal joints is discussed in Objective 8. ***Matchmarks*** are lines marked right across from each other on two adjacent components or parts so that when the parts are reassembled they can be placed in their original position to each other. Matchmarks are usually made with a permanent marker or scratched with a sharp awl.

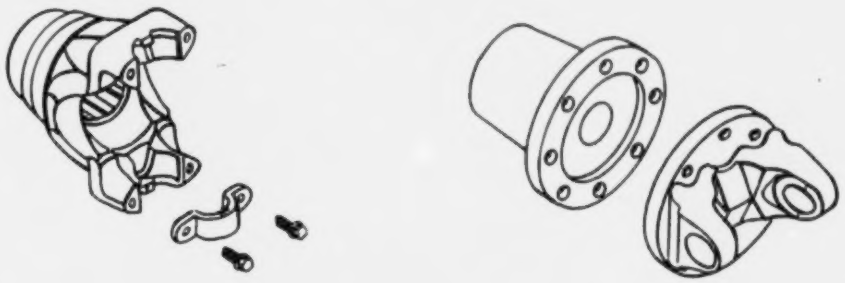
3. Put a hoist stand under the driveline so it will support the driveline when it is disconnected.

◆ WARNING ◆

The driveline is an extremely heavy component. You will need the help of an assistant to remove it safely.

4. Disconnect the rear universal joint from the differential using the method appropriate to the connection. (Figure 1)

FIGURE 1



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There are several different ways that the driveline can be connected to the differential.

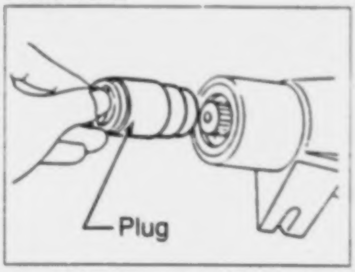
5. Wrap masking tape around the bearing cups on the rear universal joint to keep them from falling off as the driveline is removed.
6. Supporting the driveline along its length, slip it toward the front of the vehicle and lower it only enough to clear rear axle housing.

CAUTION

Do not allow the driveline to hang from the front universal joint or allow any universal joints to bend to an extreme angle. Damage will result.

7. Gently slide the driveline out of the transmission extension housing.
8. Carefully set the driveline where it is safe from accidental damage.
9. Place a plastic plug, shop cloth, or rag into end of the transmission extension housing to stop transmission lubricant from leaking. (Figure 2)

FIGURE 2



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PROCEDURE

Replace the driveline

1. Reassemble the driveline components, making sure matchmarks are aligned.
2. Wipe the front slip joint clean.
3. Place a small amount of grease or transmission lubricant on the slip joint's internal splines.
4. Supporting the driveline along its length, align matchmarks and slide the slip joint shaft into the extension housing tube.

CAUTION

Do not force the slip joint. If the shaft does not slip easily into the transmission extension housing, check the slip joint for damage, incorrect alignment, or insufficient lubrication.

5. With an assistant supporting the driveline, align the matchmarks and reassemble the differential connection. If bolts are used, use Supplement 7, "Torquing a Bolt," to torque them to specification.

   NOTE: Overtightening bolts can cause vibration. Undertightening them can cause noise.

6. Manipulate the driveline components and make sure they operate freely.

7. Check the universal joint angles. (Job Sheet 1)

8. Check the transmission lubricant level and add oil if needed.

9. While the vehicle is still on the hoist, make sure the wheels and driveline are clear of obstructions and can rotate freely.

10. Have an assistant start the engine, place the transmission in gear, and run the vehicle at different speeds.

    ◆ WARNING ◆

    Keep clear of the rotating driveline.

11. Check for driveline noise and vibration.

12. Stop the engine.

13. Make adjustments as needed.

14. Lower the vehicle on the hoist.

15. Use Supplements 3, 4, and 5 to make a road test for driveline vibration and noise.

16. Make needed adjustments.

17. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 4 SERVICE DRIVELINES I

OBJECTIVE 11D **Inspect, remove, and replace a simple universal joint.**

INTRODUCTION

If your inspection of the simple universal joints indicates any obvious damage, if a joint is tight, or if there is any looseness between the spider and yokes, the joint will have to be removed and inspected. *If any part of the joint is worn or damaged, the entire joint must be replaced.* Replacing a simple universal joint is the most frequent driveline service.

One of the first things to notice about a simple universal joint is how the bearing cups are held in the yokes. If metal retainer rings are used, it is possible for the joint to be removed, cleaned, relubricated, and reassembled, replacing only the seals. If injected plastic retainer rings are used, the entire joint must be replaced. In either case, repair or replacement kits are available from the manufacturer.

A bench vise, arbor press, U-joint press, or special U-joint tool similar to a C-clamp may be used in removal and replacement.

♦ WARNING ♦

Be particularly careful to wear safety glasses during this entire procedure; retainer rings, needle bearings and other small parts can spring up and damage your eyes.

EQUIPMENT AND MATERIALS

- Driveline which has a simple universal joint
- Appropriate service manual
- Eye protection
- Shop light
- Indelible marker or sharp awl
- Bench vise, arbor, U-joint press, or U-joint tool
- Shop cloth
- Penetrating oil
- Approved cleaning solvent
- Crocus cloth
- File
- Needle-nose pliers
- Snap-ring pliers
- Thin-bladed screwdriver
- Two 9/16" sockets from a socket wrench
- One 1-1/8" socket from a socket wrench
- Hand grease gun
- Soft-faced mallet
- Simple universal joint repair or replacement kit

- Chassis grease if none is included in kit

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The driveline should be removed from the vehicle. (Job Sheet 3)

PROCEDURE

Inspect a simple universal joint

With the driveline still on the vehicle:

1. Use a shop light to inspect the joint for signs of leaking lubricant or obvious damage.
2. Pry inside the joint with a screwdriver for signs of looseness or stiffness.
3. Notice red powder around trunnions, an indication of a failed seal or rusted bearings.

With the driveline removed from the vehicle:

4. Stand the driveline on end with one end resting on the floor.
5. Hold the driveline with one hand and rotate the joint, feeling for any looseness, stiffness, lumpiness, or noise.

PROCEDURE

Remove a simple universal joint

1. Prepare a work area so that you can keep track of small parts.
2. Support the driveline along its length while you are removing the simple universal joint from the driveshaft.

   CAUTION

   Do not allow any universal joints to bend to an extreme angle or the driveline may be damaged.

3. Use a permanent marker or a sharp awl to mark the joint and adjacent driveline components with matchmarks so that they can be reassembled in the same position.
4. If there is a possibility that the joint is to be reassembled rather than replaced, mark *all* the joint parts so they can be reassembled in the same position.

5. Tighten one of the simple universal joint yokes in a bench vise.

CAUTION

Never clamp a driveshaft in a vise. Clamp the yoke only.

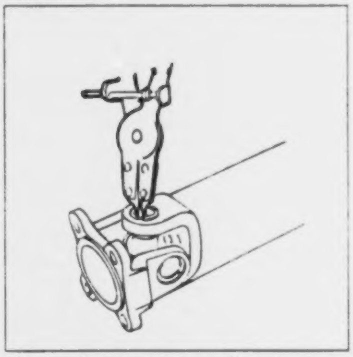
6. Apply penetrating oil to the U-joint bearing cups and retainer rings.

7. Remove the retainer rings using needle-nose pliers, a thin-bladed screwdriver, or snap-ring pliers. (Figure 1)

NOTE: Original equipment retainer rings on newer model vehicles are made of injected plastic and will be broken rather than removed during this step.

8. Loosen the vise.

FIGURE 1



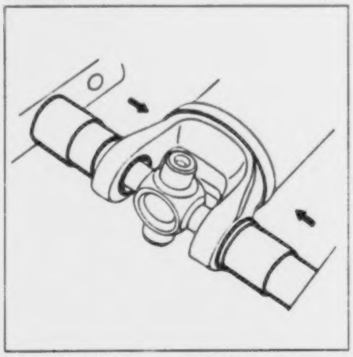
Used with permission of Chrysler Corporation.

9. Place the open end of a 1⅛ inch socket against the yoke, surrounding the bearing cup on one side of the joint. (Figure 2)

10. Place the closed end of a 9/16 inch socket against the bearing cup on the opposite side of the yoke.

NOTE: If the socket sizes suggested do not completely surround the bearing cup on one side and fit completely inside the diameter of the bearing cup on the other, select sizes which do.

FIGURE 2



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11. Holding the sockets in place, tighten the vise until it holds the sockets against the yoke.

12. Make sure the sockets are correctly in place.

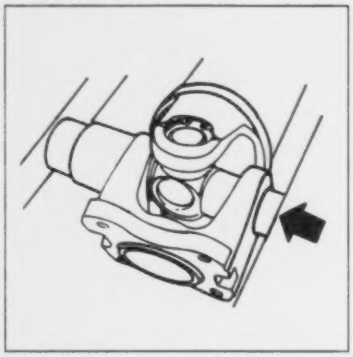
13. Slowly tighten the vise until the smaller socket clears the inside of the yoke. The bearing cup will be pushed into the larger socket. (Figure 3)

CAUTION

Do not let the spider or grease fitting (if present) press against the yoke. This will damage the joint and/or the yoke.

14. Loosen the vise and remove the joint and sockets.

FIGURE 3



Used with permission of Chrysler Corporation.

15. If the bearing cup does not come out entirely, place the protruding cup in the vise and tighten slightly.

16. Tap the yoke on the side opposite the cup with a soft-faced mallet until the cup is free.

    NOTE: Another method of releasing the bearing cup is to grasp it with needle-nose pliers and work it loose.

17. If the joint is to be reassembled, keep the bearing cup, needle bearings, seals, and retainer ring from each trunnion together and separate.

18. Loosen the vise and reverse the sockets.

19. Remove the opposite bearing cup in the same way.

20. Repeat the procedure, removing the other two bearing cups.

21. Examine each part for rippling, pitting, or other damage or wear.

    NOTE: Rippling grooves on a trunnion is a condition called ***brinelling*** and is caused by inadequate lubrication or excessive load on the joint.

22. Examine the yokes for burrs or rough spots.

23. If burrs are small, they can be smoothed with a file or crocus cloth.

24. If damage or wear is present, replace the joint.

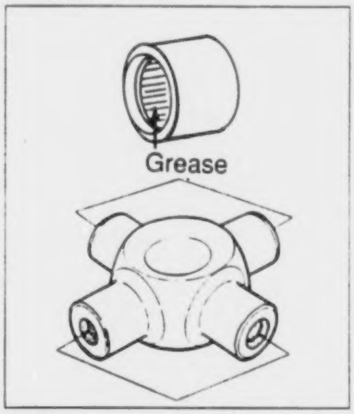
25. If the joint is to be reassembled, clean all parts in an approved cleaning solvent and dry with a shop cloth.

PROCEDURE

Replace a simple universal joint

1. Replace the rear simple universal joint first.
2. Place the new joint kit or the clean, dry parts of the old joint on a shop towel.
3. If the bearing cups are not preassembled, place a thin coat of grease on the inside of a bearing cup. (Figure 4)
4. Put the needle bearings in one by one, allowing the grease to hold them in place.
5. Slide the last bearing in from the end.
6. Install a new seal, even if you are reassembling an old joint.

FIGURE 4



Used with permission of Chrysler Corporation.

7. Repeat this procedure for the remaining bearing cups.
8. If the spider is not prelubricated, use a hand grease gun to fill the grease reservoir in the end of each trunnion.

   NOTE: Fill the grease reservoir from the bottom, making sure there are no air pockets. If the replacement spider comes with a zerk, refer to the instructions.

9. Place the spider in the driveshaft yoke.

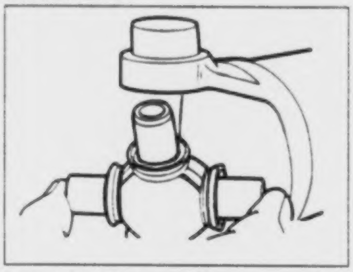
   NOTE: Align matchmarks on reassembly.

10. Push one of the bearing cups partially into the hole in the yoke. (Figure 5)

11. Place the yoke in an open vise.

12. Place the closed end of a 9/16″ socket against the bearing cup.

FIGURE 5



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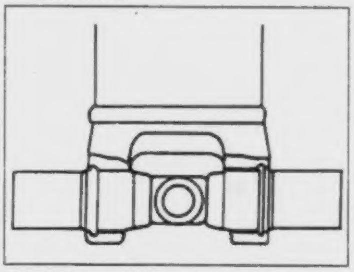
13. Place the closed end of another 9/16″ socket against the trunnion. (Figure 6)

    NOTE: If a 9/16″ socket does not fit within the hole in the yoke, select a socket which does.

14. Tighten the vise slightly, until it just holds the sockets.

15. Make sure the sockets are correctly aligned.

FIGURE 6



Used with permission of Chrysler Corporation.

16. Slowly tighten the vise until the bearing cup is pushed flush with the yoke.

    CAUTION

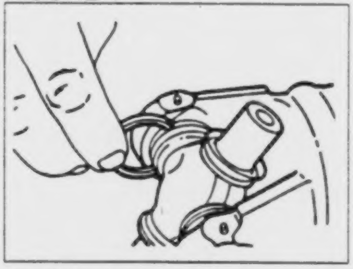
    Do not let the spider or greasing fitting press against the yoke.

17. Install the retainer ring in the groove on the spider inside the yoke. (Figure 7)

18. Repeat the procedure, installing the bearing cup on the opposite side.

19. Loosen the vise and adjust it to hold the yoke.

FIGURE 7



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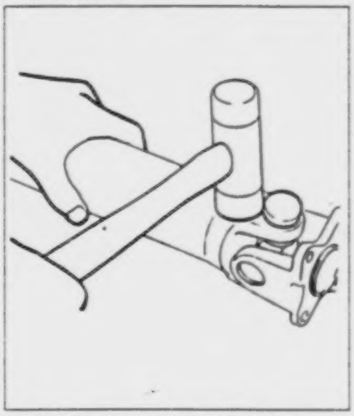
20. Tap the yoke with a brass or soft-faced mallet to insure that the retainer rings are properly seated. (Figure 8)

CAUTION

Do NOT strike the bearing cups.

NOTE: How the two remaining bearing cups are installed depends upon the type of differential connection.

FIGURE 8



Used with permission of Chrysler Corporation.

21. If the bearing cups are held by straps or U-bolts, place the two bearing cups on the trunnions and push them into place.

22. Install the retainer rings.

23. Tape the bearing cups to the joint.

24. If the bearing cups are held in a flange yoke, repeat the same procedure used to install the first two bearing cups.

25. Check the joint to make sure it moves freely.

26. If there is any binding, hold the driveshaft and tap the yokes sharply to seat the needle bearings.

27. Install the front universal joint.

28. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 5

SERVICE DRIVELINES

I

OBJECTIVE 11E

Inspect, remove, and replace other driveline joints.

INTRODUCTION

When slip joints and double Cardan universal joints are worn or damaged, the joints are not usually serviced or repaired. Any procedure which might repair either of these two joints would be very costly, both in terms of specialized equipment required and in time expended. The cost for the special equipment and hours spent in repair would cost far more than it would to purchase a replacement component. It is more cost-effective to simply replace these joints and the driveline components to which they are connected.

EQUIPMENT AND MATERIALS

- Driveline which has a slip joint and a double Cardan joint
- Appropriate service manual
- Eye protection
- Indelible marker or sharp awl for making matchmarks
- Shop light
- Flashlight
- Approved cleaning solvent
- Shop towel
- Thin-bladed screwdriver
- New seal for slip joint

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The driveline containing a slip joint and a double Cardan joint should be removed from the vehicle. (Job Sheet 3)

PROCEDURE

Inspect a slip joint

1. Check around the slip joint for signs of leaking lubricant.

   NOTE: Leaking lubricant or excessive looseness in a slip joint may be a sign of worn or damaged splines, seals, or extension housing bushing. No motion at all can indicate a stiffened slip joint seal.

2. Twist the joint, moving it up and down and back and forth.

3. Look for premarked arrows or mark the slip joint shaft and tube before separating them so they can be replaced in the same position.

4. Remove the shaft from the tube and use a shop towel and approved cleaning solvent to clean off old grease and dirt from the joint.
5. Use a flashlight to inspect the transmission housing bushing for damage or wear.
6. Inspect the slip joint oil seal.

   NOTE: Replace the slip joint oil seal routinely, even if the slip joint itself is not replaced.

7. Run your fingers over the slip joint splines to check for burrs or damage.

   CAUTION

   Burrs can cut your fingers.

8. Check the slip joint yoke for cracks or damage.

PROCEDURE

Inspect a double Cardan joint

1. Inspect the joint for signs of leaking lubrication or obvious damage.
2. Pry inside the joint with a screwdriver for signs of looseness or stiffness.
3. Notice red powder around trunnions, an indication of a failed seal or rusted bearings.
4. Hold the driveshaft with one hand and rotate the joint, feeling for any looseness, stiffness, lumpiness, or noise.

PROCEDURE

Remove and replace other driveline joints

1. Use the procedures for removing a simple universal joint (Job Sheet 4) to remove a slip joint yoke or double Cardan joint from the driveline.
2. Reinstall the yoke of a new slip joint in the same way that a simple universal joint is replaced. (Job Sheet 3)
3. If a double Cardan joint needs to be replaced, the replacement joint will come preassembled and attached to the driveline. Replace the entire driveline.
4. Reinstall the driveline, following procedures outlined in Job Sheet 3.
5. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 6 — SERVICE DRIVELINES

I

OBJECTIVE 11F

Check companion flange runout.

INTRODUCTION

The driveline's rear universal joint is connected to the companion flange on the differential. Companion flange runout—when the surface of the companion flange is not even—will cause noise and vibration in the driveline. Companion flange runout should be checked to eliminate it as a possible cause of driveline problems.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, ***Using a Dial Indicator***
- Eye protection
- Dial indicator
- Pencil and paper
- Combination wrenches
- Permanent marker or sharp awl to make matchmarks

> **CAUTION**
> **Always** check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be raised and supported properly, and the driveline should be removed. (Job Sheet 3)

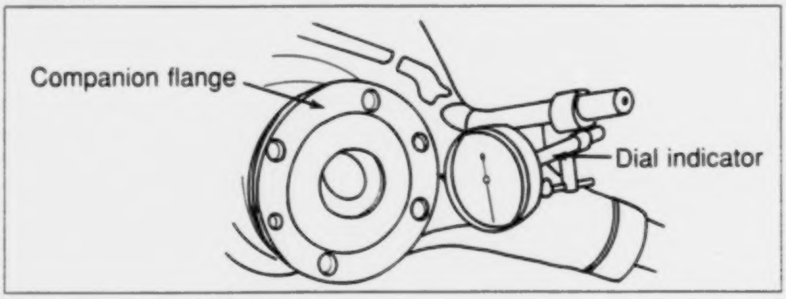
PROCEDURE

Check companion flange runout

1. Mount the dial indicator on the differential housing.

2. Position the indicator plunger at a right angle to the face of the companion flange near the outer edge of the flange. (Figure 1)

FIGURE 1

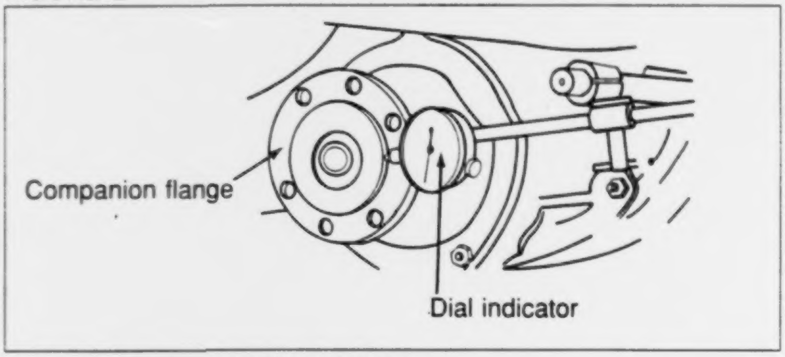


Used with permission of Ford Motor Company.

NOTE: Runout measurement made with the indicator plunger parallel to the axis of rotation measures ***lateral runout***.

3. Use Supplement 8, "Using a Dial Indicator," to position and preload the dial indicator prior to measurement.
4. Use your hand to steadily rotate the companion flange one rotation.
5. Note the indicator reading.
6. Reposition the indicator plunger at a right angle to the radial lip on the companion flange. (Figure 2)

FIGURE 2



Used with permission of Ford Motor Company.

NOTE: Runout measurement made with the indicator plunger directed to intersect at a right angle with the axis of rotation measures ***radial runout***.

7. Rotate the companion flange one rotation and note the indicator reading.
8. Compare the indicator readings with the manufacturer's specifications.
9. If companion flange runout is not within specifications, it must be corrected.

NOTE: There is a possibility companion flange runout can be corrected by removing the companion flange and rotating it. Since the companion flange is part of the differential drive pinion assembly, in removing it there is a strong possibility that certain differential adjustments will be altered and have to be readjusted, requiring additional skill and (perhaps considerable) time. See Job Sheet 6, Unit 2 for the correct procedures for removing and rotating the companion flange.

10. If the runout is not within specifications, first try rotating the companion flange and reinstalling it 180° from its original position.

11. Measure both radial and lateral runout again and if runout is still not within specifications, remove the companion flange and reinstall it 90°.

12. Re-measure radial and lateral runout and if runout is still not within specifications, replace the companion flange.

13. Re-measure radial and lateral runout on the new companion flange.

    NOTE: If you remove the companion flange, make sure the drive pinion bearing preload and the differential's ring gear tooth contact pattern remain within manufacturer's specifications.

14. If runout is still not within specifications, the drive pinion and ring gear set will have to be replaced.

15. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB
SHEET 7

SERVICE DRIVELINES

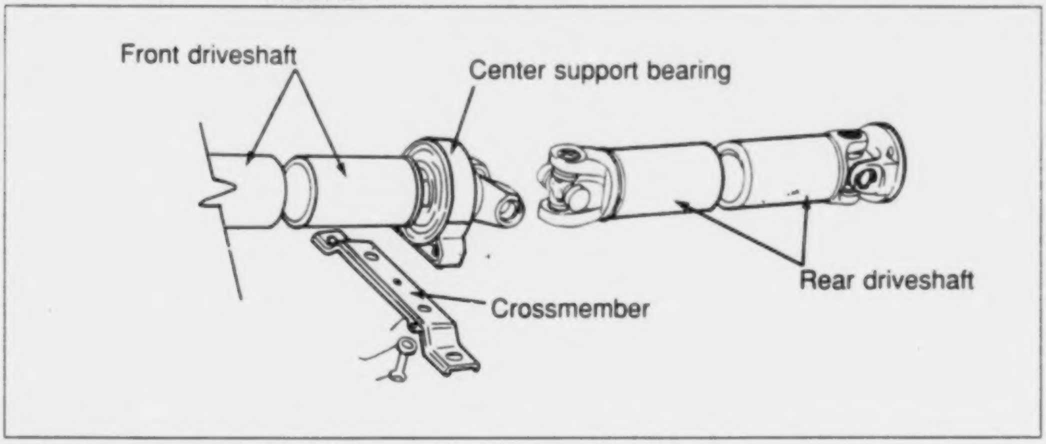
OBJECTIVE 11G

Inspect, remove, and replace a center support bearing.

INTRODUCTION

Center support bearings, found on split driveshafts, are used to support the driveline. A center support bearing is a sealed assembly and if it is dry, worn, or damaged, it is replaced rather than serviced or repaired. Center support bearings come in many different designs and are joined to the driveline in a variety of ways. (Figure 1) Because of this, there is no uniform method of removing and replacing a center support bearing. The manual drivetrain and axles technician should follow the procedures outlined in the vehicle's service manual.

FIGURE 1



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EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

> **CAUTION**
> **Always** check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect a center support bearing

1. Check the center support bearing's support bracket for looseness.
2. Shake the driveshaft near the center support bearing and listen for noise from the center support bearing.

3. Inspect the rubber bushings around the bearings for cracks and wear.

4. Inspect the rubber insulation around the center support bearing for wear and damage.

PROCEDURE

Remove and replace a center support bearing

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 1

Measure and adjust universal joint angles.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Adjusted vehicle to proper rear trim height.	_____	_____
3. Prepared vehicle and driveline following outlined procedure.	_____	_____
4. Measured universal joint angles correctly.	_____	_____
5. Adjusted front universal joint angle following outlined procedures.	_____	_____
6. Adjusted rear universal joint angle correctly.	_____	_____
7. Completed service correctly.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Check driveshaft runout and adjust minor driveshaft imbalance.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared vehicle and driveshaft as outlined by procedure.	_____	_____
3. Mounted dial indicator correctly.	_____	_____
4. Checked driveshaft runout following outlined procedure.	_____	_____
5. Calculated and evaluated driveshaft runout readings correctly.	_____	_____
6. Rotated driveline following outlined procedure.	_____	_____
7. Marked driveshaft heavy spot following outlined procedure.	_____	_____
8. Placed hose clamps to balance driveshaft correctly.	_____	_____
9. Completed service correctly.	_____	_____
10. Observed safety rules and precautions.	_____	_____
11. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 3

Remove and replace the driveline.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment, materials, and assistance.	_____	_____
2. Prepared vehicle and work area appropriately.	_____	_____
3. Marked and rematched driveline components correctly.	_____	_____
4. Handled driveline correctly throughout the procedure.	_____	_____
5. Disconnected driveline from the differential correctly.	_____	_____
6. Removed driveline following procedures outlined.	_____	_____
7. Reconnected slip joint following outlined procedures.	_____	_____
8. Reconnected rear universal joint correctly.	_____	_____
9. Completed service correctly.	_____	_____
10. Observed safety rules and precautions.	_____	_____
11. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Inspect, remove, and replace a simple universal joint.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected simple universal joint using procedures outlined.	_____	_____
3. Prepared work area and marked and rematched joint and driveshaft correctly.	_____	_____
4. Removed joint following outlined procedures.	_____	_____
5. Reassembled joint following procedures outlined.	_____	_____
6. Completed service correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 5

Inspect, remove, and replace other driveline joints.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Inspected slip joint according to outlined procedure.	____	____
3. Inspected double Cardan joint according to outlined procedure.	____	____
4. Removed and replaced slip joint as directed by instructor.	____	____
5. Removed and replaced double Cardan joint as directed by instructor.	____	____
6. Completed service correctly.	____	____
7. Observed safety rules and precautions.	____	____
8. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Check companion flange runout.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Prepared vehicle correctly.	____	____
3. Mounted dial indicator correctly.	____	____
4. Measure lateral runout according to outlined procedures.	____	____
5. Measured radial runout according to outlined procedures.	____	____
6. Followed procedures to correct runout (if present).	____	____
7. Completed service correctly.	____	____
8. Observed safety rules and precautions.	____	____
9. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 7 **Inspect, remove, and replace a center support bearing.**

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected center support bearing according to outlined procedure.	_____	_____
3. Removed center support bearing correctly.	_____	_____
4. Replaced center support bearing correctly, following the manufacturer's recommended procedures.	_____	_____
5. Completed service correctly.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criteria must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE DRIVELINES

I

NAME ______________________ SCORE ______

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive driveline by selecting the correct definition from four choices. Write the number of the correct definition in the blank.

______1. **constant velocity joints**

A. Joints which operate at a constant angle
B. Joints which operate at the same angle only if the velocity is kept constant
C. Joints which operate at a constant speed only if operation is kept at the same angle
D. Joints which operate at a constant speed of rotation regardless of the angle of operation

______2. **driveline**

A. A cable inside the steering column that transfers steering commands to the drivetrain
B. A drivetrain component that transports torque over a distance from the transmission to the differential on a front-engine, rear-wheel drive vehicle
C. A hollow tube which transfers torque across distance
D. The circuit of power from the engine to the drive wheels

______3. **driveshaft**

A. The circuit of power beginning with and including the engine and ending with the drive wheels
B. A hollow tube, part of the driveline, which transfers torque across distance
C. The shaft inside the engine which transfers the engine's driving power to the drivetrain
D. The steering column component which transfers torque

______4. **drivetrain**

A. A series of components which transports the engine's turning power from the engine to the drive wheels
B. Turning power that is transferred from one component to another in a vehicle
C. The part of the driveline which transfers torque across distance
D. A driveline component that transports torque over a distance from the transmission to the differential

______5. **matchmarks**

A. Lines placed on the head of bolts to indicte their relative strength
B. Identifying marks placed on all vehicles of the same model and year
C. Lines marked across from each other on two adjacent components or parts so that when the parts are reassembled they can be rotated so that they will wear evenly
D. Lines marked across from each other on two adjacent components or parts so that when the parts are reassembled they can be placed in their original position

______6. **power train**

A. The part of the drivetrain which transmits power
B. The part of the drivetrain where the flow of power begins
C. The circuit of power beginning with and including the engine and ending with the drive wheels
D. The circuit of power which transmits torque from the engine to the transmission

______7. **rear-end torque**

A. Engine power that has been increased by the gear action of the vehicle's transmission
B. The turning power that propels the drive axles
C. The powerful twisting action the driveline exerts on the differential and rear axle housing
D. What torque is called in a rear-wheel drive vehicle

______8. **runout**

A. The fluid used in a hydraulic driveline
B. The distance the surface or edge of a rotating part moves in or out during rotation
C. The operating angle of a universal joint
D. The distance a slip joint moves in and out while transmitting torque

______9. **speed fluctuation**

A. Speed change in a driveline component
B. Speeding up and slowing down in a component which should operate at an even speed
C. Operating at an even flow of power
D. The flow of power through the drivetrain

_____10. **split driveshaft**

A. A driveline containing two or more driveshafts
B. A driveshaft laminated with a rubber sleeve
C. A driveshaft that uses split boots
D. A driveshaft that contains a slip joint

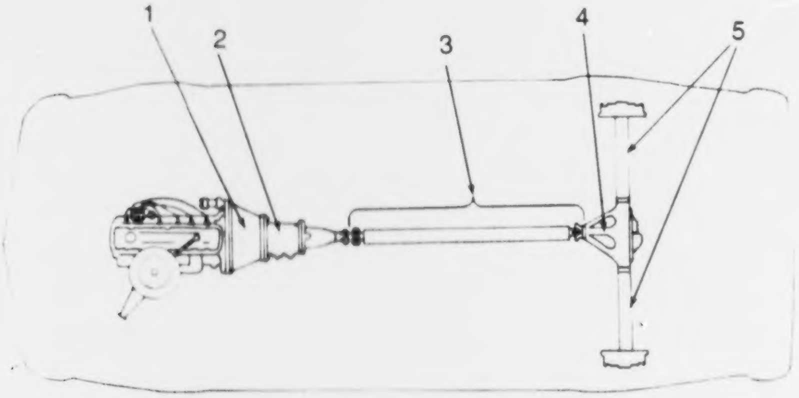
_____11. **torque**

A. Force used to hold a rotating part
B. Twisting motion
C. Tightening a bolt
D. Turning power

_____12. **universal joint**

A. A type of joint which transmits torque while maintaining the same speed
B. A type of replacement joint which is useful under a variety of conditions
C. A type of joint which transmits torque while maintaining the same angle
D. A type of joint which transmits torque while allowing for angle changes

OBJECTIVE 2 **Label the components of a rear-wheel drivetrain on an illustration.** Write the name of the correct component in the corresponding blank.



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NOTE: Some components are pictured inside their housings.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

OBJECTIVE 3 **Match the function of rear-wheel drivetrain components with the name of the component by choosing the correct term from a list of three choices.**

______1. A gear assembly that accepts the torque from the driveline and divides and distributes it to the drive axles in such a way that the axles are able to turn at different speeds when turning a corner

A. transmission
B. clutch
C. differential

______2. The shafts that transmit the torque from the differential to the drive wheels to propel the vehicle

A. driveshafts
B. drive axles
C. drive wheels

______3. The drivetrain component that transports torque over a distance from the transmission to the differential

A. driveline
B. transmission
C. torque drive

______4. A drivetrain component that connects and disconnects the engine from a manual transmission or transaxle

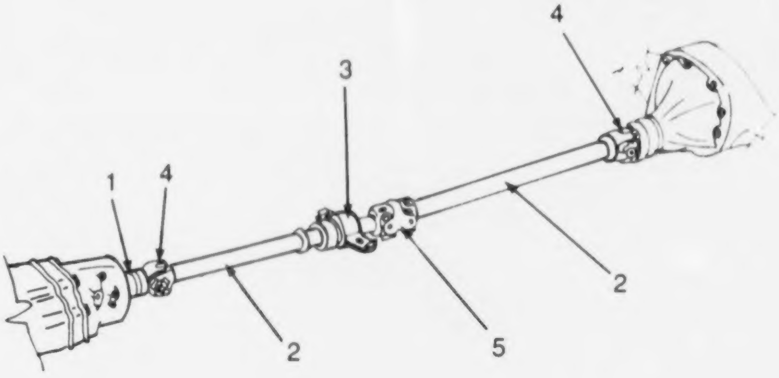
A. differential
B. driveline
C. clutch

______5. A series of gears that multiplies and adjusts the engine's torque to driving requirements before transmitting it to the driveline

A. differential
B. transmission
C. clutch

OBJECTIVE 4

Label the components of a driveline on an illustration. Write the name of the correct component in the corresponding blank.



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1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

OBJECTIVE 5

Match the names of driveline components to phrases describing the components or giving their functions. Put the letter of the correct driveline component in the space before the phrases describing it or its function.

______1. A sealed prelubricated bearing assembly surrounded by rubber insulation, it circles the driveshaft and is bolted to the chassis

______2. Allows the driveline to adjust to angle changes between the transmission and differential while continuing to transmit torque

______3. Transfers torque across distance

______4. Consists of a cross-shaped centerpiece which swivels between two separate sets of yokes

______5. Shortens or lengthens to allow the driveline to adjust to distance changes between the transmission and differential

______6. Most are thin-walled, hollow metal tubes with permanent yokes welded on each end

______7. Supports the driveline and allows it to rotate easily

______8. Its simple construction consists of a shaft which slips into a tube

A. Driveshaft

B. Universal joint

C. Slip joint

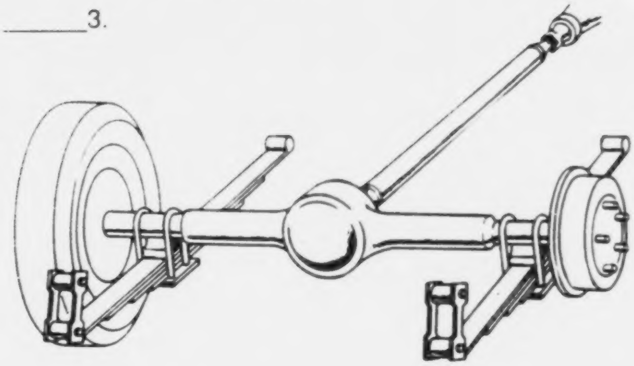
D. Center support bearing

OBJECTIVE 6

Match the names of the two types of drivelines to illustrations or written descriptions of each. Put the letter of the driveline type before the correct description or illustration.

_______1. The driveline remains open and rear-end torque is absorbed by the vehicle's rear suspension and by the use of universal joints at both the front and rear of the driveline	A. Torque-tube drive B. Hotchkiss drive
_______2. A solid steel driveshaft rotates inside a hollow metal tube which is bolted to the differential housing	

_______3.



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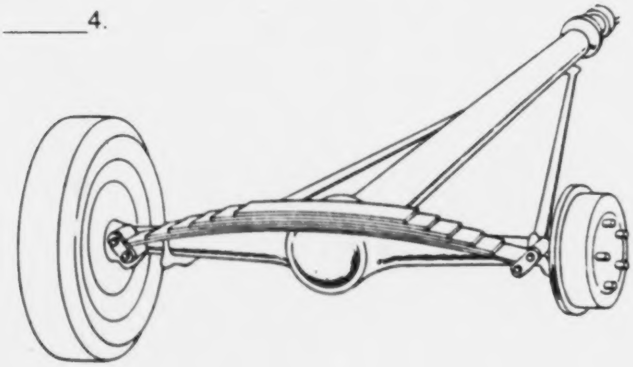
_______4.



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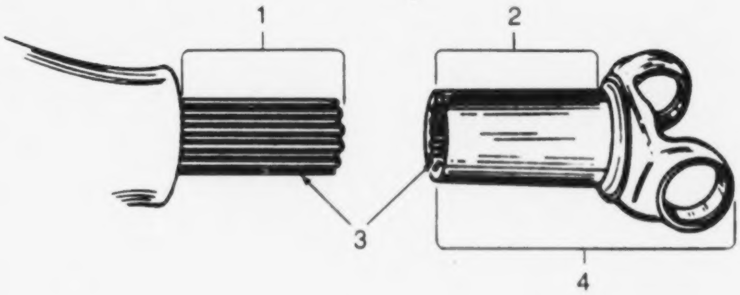
OBJECTIVE 7 **Write down at least four of the five methods of controlling driveline vibration.**

1. ____
2. ____
3. ____
4. ____

OBJECTIVE 8 **Write down the two methods of eliminating driveline speed fluctuations.**

1. ____
2. ____

OBJECTIVE 9 **Identify the major types of driveline joints and their parts by writing the correct names for given illustrations.**



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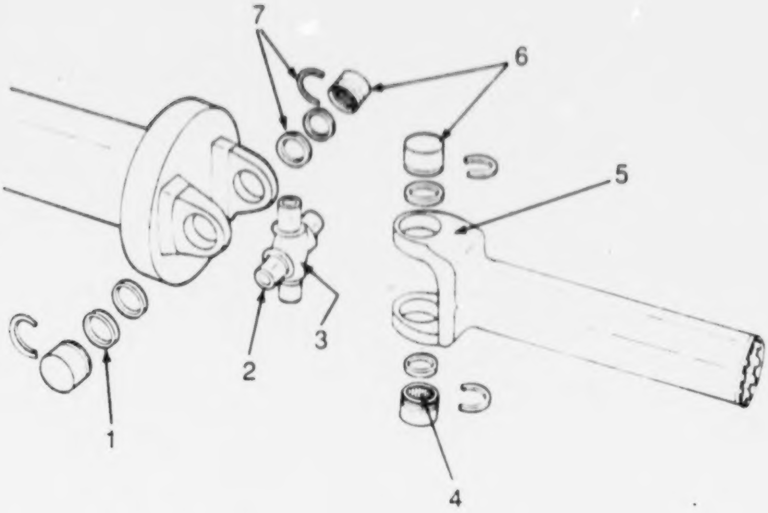
A. Type of joint: ________________________________

Parts:

1. ____
2. ____
3. ____
4. ____



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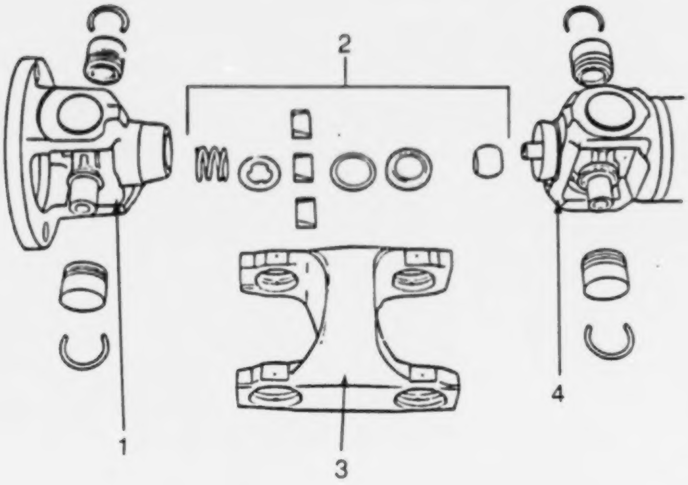
B. Type of joint: ______________________________

Parts:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________



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C. Type of joint: ______________________________

Parts:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

WRITTEN TEST ANSWERS

SERVICE DRIVELINES

I

OBJECTIVE 1

1. D
2. B
3. B
4. A
5. D
6. C
7. C
8. B
9. B
10. A
11. D
12. D

OBJECTIVE 2

1. Clutch
2. Manual transmission
3. Driveline
4. Differential
5. Drive axles

OBJECTIVE 3

1. C
2. B
3. A
4. C
5. B

OBJECTIVE 4

1. Slip joint
2. Driveshaft
3. Center support bearing
4. Simple universal joint
5. Double Cardan joint

OBJECTIVE 5

1. D
2. C
3. A
4. B
5. C
6. A
7. D
8. C

OBJECTIVE 6

1. B
2. A
3. B
4. A

OBJECTIVE 7

Answers should include **four** of the following:

- Shorter driveshafts
- Driveshaft balance weights
- Special driveshaft designs
- Shaft vibration damper
- Vibration absorber

OBJECTIVE 8

Answers should include both of the following:

- Phase the universal joints and have them both operate at the same angle
- Constant velocity universal joints

OBJECTIVE 9

A. Slip joint
   1. Shaft
   2. Tube
   3. Splines
   4. Slip yoke

B. Simple universal joint
   1. Seal
   2. Trunnion
   3. Cross or spider
   4. Bearings
   5. Yoke
   6. Bearing cups
   7. Retainer ring

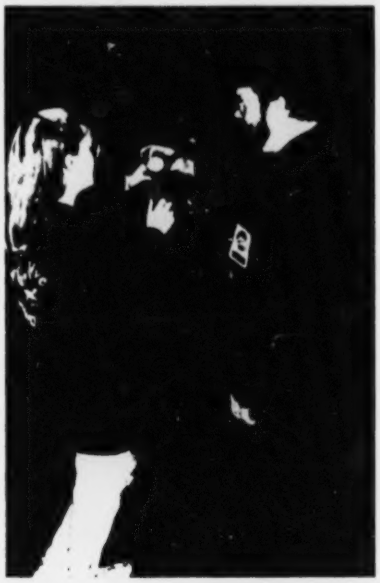
C. Double Cardan joint
   1. Centering stud yoke
   2. Centering assembly
   3. Coupling yoke
   4. Ball stud yoke

OBJECTIVE SHEET

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

INTRODUCTION



In rear-wheel drive vehicles, the driveline transports the engine's turning power to the differential and the rear drive axles, which propel the vehicle. This transfer of high-speed torque is accomplished through the use of gears and shafts, but the design features of the differential and drive axles allow these components to perform their functions with a minimum of attention from the Drivetrain and Axles Specialist. Understanding basic concepts relating to the operation of the differential and rear drive axles will help you understand similar functions and components that are used in front-wheel drive and four-wheel drive vehicles.

PREREQUISITES

Before studying this unit, the student must have successfully completed Unit 1, *Drivelines*.

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose differential and rear drive axle problems and service and repair these components. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Choose the correct definitions for terms associated with the automotive differential and rear drive axles by selecting the correct definition from four choices.
2. Match the names of the parts of a gear and a gear tooth to illustrations.
3. Match the names of common gear types with illustrations of the gears.
4. Label illustrations of the two types of rear axle housings with their correct names.

5. Label three types of antifriction bearings and match the names of their parts to illustrations.

6. Label the two types of rear drive axles and their parts on illustrations.

7. Write the four functions of a differential.

8. Match the names of the parts of a conventional differential to an illustration.

9. Distinguish between the functional operation of a conventional and a limited-slip differential.

10. Label two main types of limited-slip differentials and match the names of their parts to illustrations.

11. Determine needed differential adjustments by examining illustrations of ring gear tooth contact patterns.

12. Diagnose differential and rear axle leak, noise, and performance problems. (Assignment Sheet 1)

13. Demonstrate the ability to:

    A. Inspect the rear axle housing and flush and refill the rear axle lubricant. (Job Sheet 1)

    B. Remove rear axle shafts. (Job Sheet 2)

    C. Measure ring gear runout. (Job Sheet 3)

    D. Check ring gear tooth contact patterns. (Job Sheet 4)

    E. Measure and adjust side bearing preload and ring to pinion gear backlash. (Job Sheet 5)

    F. Remove, inspect, and replace a companion flange and pinion seal. (Job Sheet 6)

    G. Remove the differential case assembly and clean and inspect the differential housing. (Job Sheet 7)

    H. Remove, inspect, and replace a ring gear. (Job Sheet 8)

    I. Measure differential case runout. (Job Sheet 9)

    J. Remove, inspect, and replace differential side bearings. (Job Sheet 10)

K. Remove, inspect, measure, adjust, and replace the parts of a conventional differential case assembly. (Job Sheet 11)

L. Remove, inspect, measure, adjust, and replace limited slip differential components. (Job Sheet 12)

M. Remove and inspect a drive pinion gear assembly. (Job Sheet 13)

N. Measure and adjust drive pinion depth. (JoQMS PS Jet +/800 II/810/JetScriptQMPSJEII.PRSreload. (Job Sheet 15)

P. Replace and adjust the differential case assembly. (Job Sheet 16)

Q. Inspect and replace rear axle shaft wheel studs. (Job Sheet 17)

R. Remove, inspect, and replace rear axle shaft seals and bearings. (Job Sheet 18)

S. Remove and replace axle shaft pressed-on bearings and retainers. (Job Sheet 19)

T. Replace rear axle shafts. (Job Sheet 20)

U. Measure rear axle and axle flange runout and shaft end play and complete differential and rear drive axle service. (Job Sheet 21)

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

PREPARATION

Review unit and plan presentation

- Study the specific objectives to determine the order in which you will present the objectives. Decide whether or not you wish to add additional objectives.
- Review teaching suggestions given in the Delivery section and plan classroom activities.
- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.
- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

Obtain supplemental materials

- Order films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrates job sheet skills. Videotape your own procedures if unable to obtain suitable media.
- Copies of current articles on subjects covered in this unit may be obtained by writing to the *Automotive Information Council's* Reference Center. They will also conduct a computer search for such articles. See the note in the section on Media for more information about this free service.
- Obtain competency profiles for this unit.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364, 1-800-522-5810, ext. 589 in-state; 1-800-654-4502, out-of-state.

- Note equipment and material needs for completing job sheets.

Prepare classroom and shop

- Display safety signs, posters, charts that show differential and rear drive axle components and service, etc.
- Have magazine articles, specification guides, service manuals, mock-ups, and other references about the differential and rear drive axles available for student use.
- Check tools and equipment against job sheet requirements.

Administer Pretest

- Administer the Pretest.
- Use the Pretest results to assess student competencies, considering the results as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the introduction to the unit in the Objective Sheet.
- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive Drivetrain and Axles Specialist.
- Raise a front-engine rear-wheel drive vehicle on a hoist and show the students the systems and components covered by this unit. Use this opportunity to show them the method that will be used in your shop for exposing a vehicle's rear axle and differential for service.
- Discuss with the students the fact that the material in this unit applies to vehicles which have a front-engine and a rear-wheel drive. Point out that many modern automobiles now have front-wheel drive, but that trucks and larger automobiles still have rear-wheel drive configuration.
- Explain that basic information learned in this unit will also be applied later in units which apply to front-wheel drive and four-wheel drive vehicles. For example, the functioning of a differential, information on bearings and seals, etc.

- Show the students that the job sheets in the unit are normally listed in the order they must be performed. Some tasks must be performed before others can be performed successfully. **This order is important** in the classroom and on the job. However, because procedures on different vehicles vary, the vehicle's service manual should always be consulted to assist in identifying the proper diagnosis, service, or repair sequence. Assist the students to identify the logic in this order as you work through the unit.

- Look at one of the later job sheets. Point out that the preparation and procedures that need to be completed before beginning the job sheet are described before the procedures are listed. The job sheet number in parenthesis refers to the job sheet which will instruct them how to perform that preliminary preparation or procedure.

Objective 1 Choose the correct definitions for terms associated with the automotive differential and rear drive axles by selecting the correct definition from four choices.

- Show examples of terms where applicable.

- Explain that students will find that these terms are sometimes used differently in other service manuals and automotive materials.

- Discuss how to calculate a gear ratio. Give students actual gears or pictures of gears and have them work in pairs to calculate the gear ratios of the examples.

Objective 2 Match the names of the parts of a gear and a gear tooth to illustrations.

- Pass out gears and let students handle them while you point out the parts of a gear and gear tooth.

- Show students where the pressure is applied on the gear tooth when the gear is in use.

- Use the gears to review and reinforce the terminology in Objective 1 which applies to gears.

  EXAMPLE: axis, backlash, mesh, pinion gear, etc.

Objective 3 Match the names of common gear types with illustrations of the gears.

- Show the film, *Gears and Gear Drives.*

- Allow the students to handle examples of the various types of gears.

- Using actual gears, divide the class into pairs and have the students quiz each other on the names of the various gear types.

- Use an illustration (See Objective 8.), transparency, or chart to show students the type of gears that are used in the differential.

Objective 4 Label illustrations of the two types of rear axle housings with their correct names.

- Show the students vehicles which have both types of rear axle housings. Raise the vehicles and point out the various component parts.

- Show the students how to raise and prepare vehicles with each type of axle housing for service or repair.

- Point out the location of *the differential identification code* on the vehicle you are using. Refer to the vehicle's service manual to demonstrate what information this code tells the specialist about the vehicle's differential.

Objective 5 Label three types of antifriction bearings and match the names of their parts to illustrations.

- Show the film, *Bearings*.

- Pass out different types of antifriction bearings and let the students handle them while you point out the various parts.

- Explain the boxed material on "Bearing Load" and stress the importance of this information when replacing bearings with the recommended type.

- Review Supplement 5, "Cleaning, Inspecting, and Lubricating Antifriction Bearings."

- Demonstrate the procedures outlined in Supplement 5 for cleaning and lubricating antifriction bearings.

- Have the students perform the activities outlined in Supplement 5.

- Supplements 6 and 8 on straight and tapered roller bearing damage diagnosis can be covered at this point or with Job Sheet 10.

Objective 6 Label the two types of rear drive axles and their parts on illustrations.

- Show the students examples of the two types of rear drive axles, pointing out their structural differences.
- Display axles with flanged ends and tapered ends and show how the wheels are attached to each type.

Objective 7 Write the four functions of a differential.

- Show the first part of the filmstrip, *The Automotive Differential*, on "Basic Parts and Operation."
- Explain the functions of a differential.
- Compare the function of the differential in a rear-wheel drive, front-wheel drive, and four-wheel drive vehicle.

Objective 8 Match the names of the parts of a conventional differential to an illustration.

- Point out the parts of a conventional differential on a model or actual differential.
- Explain the boxed material, "Power Flow in a Conventional Differential," showing the students on a model how the power flows through the differential.
- Rotate the companion flange and demonstrate how the parts of the differential interact during operation.
- Discuss the boxed material, "Adjusting Power Flow to Turn a Corner."
- Go over Supplement 10, "How to Figure Ring to Drive Pinion Gear Ratios," with the class.
- Have students complete Activity Sheet 2, "Figuring Ring to Drive Pinion Gear Ratios."

Objective 9 Distinguish between the functional operation of a conventional and a limited-slip differential.

- Show the video, *The Limited-Slip Differential: Pinion Operation and Service*.
- Use models or actual differentials to help explain the difference in the way a conventional and a limited slip differential operate.

- Discuss what types of vehicles might take advantage of the differences offered by the limited-slip differential.

Objective 10 Label two main types of limited-slip differentials and match the names of their parts to illustrations.

- Show models or actual differentials of the two main types of limited-slip differentials and demonstrate how the two types operate.

- Have the students use the vehicle service manuals available in the classroom to research the differences in the many "types" of limited-slip differentials. Have each student write down (1) what the limited-slip differential in the manual is called, (2) what year, make, and model vehicles use this differential, and (3) how it is different from the examples shown in Objective 10. Give extra credit if they can discover how the manufacturer believes this limited-slip differential is different or better than others. Have each student give an oral report to the class on his findings.

Objective 11 Determine needed differential adjustments by examining illustrations of ring gear tooth contact patterns.

- Demonstrate the procedure for making a ring gear tooth contact pattern check and use the patterns that are made to discuss determining needed differential adjustments from ring gear tooth contact patterns.

- Discuss the boxed material on "Gear Tooth Contact Patterns."

- Have the students complete Activity Sheet 1, "Use Ring Gear Tooth Contact Patterns to Determine Needed Differential Adjustments."

APPLICATION

Objective 12 Diagnose differential and rear axle leak, noise, and performance problems. (Assignment Sheet 1)

- Show the film, *Rear Axle Diagnosis and Servicing*, and the video, *Rear Axle Diagnosis and Overhaul*.

- Use a raised vehicle to discuss Supplement 2, "Rear Axle/Differential Lubrication Leak Diagnosis Chart," pointing out the location and nature of the various possible lubrication leaks.

- Review Supplement 3, Unit 1, "Making a Diagnostic Road Test."

- Use Supplement 3, "Rear Axle/Differential Noise Diagnosis Chart," in discussing the material in Supplement 1, "Making a Rear Axle/Differential Noise Diagnosis."

- Show and discuss the differential and rear drive axle noises on the filmstrip, *Noise, Vibration, and Harshness*, and/or the video, *NVH Vehicle Diagnosis*.

- Give the students a "sound" quiz over the differential and rear drive axle noises on the filmstrip or video.

- Demonstrate how to make the visual inspection called for in Supplement 1, "Making a Rear Axle/Differential Noise Diagnosis."

- Have the students complete Assignment Sheet 1, using Supplements 1, 2, 3, & 4.

Objective 13A Inspect the rear axle housing and flush and refill the rear axle lubricant. (Job Sheet 1)

- Demonstrate how to clean or steam clean the outside of an axle housing. Discuss this procedure as a diagnostic tool.

- Show the class an example of casting porosity and demonstrate how to peen the porosity with body lead.

- Distribute samples of crocus cloth and explain its use in smoothing parts and components. Caution students about overuse.

- Display examples of lube guns, suction guns, and syringes that might be used in replacing rear axle lubricant and demonstrate the use of each.

- Discuss the selection of rear axle lubricant, stressing the damage that can be done by using the wrong lubricant and the importance of checking the service manual for lubrication specifications, particularly on vehicles with limited-slip differentials.

- If the students will need to remove the rear cover of an integral carrier housing in order to complete Job Sheet 1, review with them Supplement 7, Unit 1, "Torquing a Bolt."

- Review and demonstrate other tasks in Job Sheet 1.

- Have students complete Job Sheet 1.

Objective 13B Remove rear axle shafts. (Job Sheet 2)

- Show the video, *Axle Carrier Overhaul.*
- Review safety rules and precautions for working under a vehicle.
- Demonstrate how to use a slide hammer.
- Have the students read Supplement 9, "Asbestos," and discuss the material with them before continuing to removing the drive wheels and brake linings.
- Demonstrate how to remove the drive wheels and brake linings in preparation for removing or servicing the drive axles.
- Have students practice raising and supporting the vehicle and removing the wheels and brake drums before beginning the job sheet.
- Demonstrate the procedures in Job Sheet 2 on both axles secured by C-locks and axles secured by retainer plates.
- Have students complete Job Sheet 2.

Objective 13C Measure ring gear runout. (Job Sheet 3)

- If the vehicle you are using has a removable carrier housing, use Job Sheet 7 to demonstrate how to remove the carrier and install it in a differential holding fixture.
- Use a differential to show the students an example of ring gear runout.
- Discuss the causes of ring gear runout, stressing the importance of torquing the ring gear bolts to specifications as a critical first step.
- Show the students how to locate the manufacturer's specifications for differential and rear drive axle service in a vehicle service manual.
- If necessary, review Supplement 8, Unit 1, "Using a Dial Indicator."
- Demonstrate the procedures in Job Sheet 3.
- Have students complete Job Sheet 3.

Objective 13D Check ring gear tooth contact patterns. (Job Sheet 4)

- Use a ring gear and drive pinion gear to demonstrate the way the two gears mesh and how the gears would be positioned if they need adjustments for drive pinion depth or ring to pinion gear backlash.
- Demonstrate the procedures in Job Sheet 4 for a differential in both an integral carrier and a removable carrier.
- Have the students complete Job Sheet 4.
- After they have completed Job Sheet 4, have them use Information Sheet, Objective 11 to determine any differential adjustments needed.

Objective 13E Measure and adjust side bearing preload and ring to pinion gear backlash. (Job Sheet 5)

- Discuss the nature of a *press fit* between a bearing and the part to which it is attached. Show students an example of a bearing with its outer race pressed on and an example with its inner race pressed on.
- Explain the difference between *preload* and *backlash*.
- Show examples of differential side gears that are adjusted by adjusting nuts, and those adjusted by shims.
- Display a set of replacement shims. Discuss how they are sized and stored.
- Show the students a side bearing spanner wrench and a shim installer and demonstrate how to use them.
- Demonstrate the procedures outlined in Job Sheet 5.
- Have the students complete Job Sheet 5.

Objective 13F Remove, inspect, and replace a companion flange and pinion seal. (Job Sheet 6)

- Show the filmstrip, *Servicing the Axle and Differential Seals*, part 1, "Replacing the Differential Pinion Shaft Oil Seal."
- Distribute radial lip seals and use the illustration in the job sheet to review the various parts of the seal with the students. Show them where to find the part number on the seal.

- Stress the importance of installing the seal with the correct side facing the rear axle lubricant.
- Make sure the students know the importance of installing *new* seals whenever the drive pinion or rear axles are removed.
- Display several types of companion flanges, pinion nuts and washers.
- Show the students a companion flange holding tool and a companion flange remover and demonstrate how to use them.
- Show the students how to measure the torque on a rotating part. The correct performance of this procedure will be necessary elsewhere in the unit as well.
- Demonstrate the procedures used in Job Sheet 6, stressing importance of making the correct measurement of the drive pinion bearing preload and depth setting.
- Have the students complete Job Sheet 6.

Objective 13G Remove the differential case assembly and clean and inspect the differential housing. (Job Sheet 7)

- Show the filmstrip, *The Automotive Differential*, part 2, "Removal, Disassembly, and Inspection."
- Discuss the various checks that should be made before removing the differential from the housing. Explain the necessity of these checks in preliminary diagnosis of differential problems.
- Show how to install a carrier in a carrier holding fixture.
- Demonstrate the procedures used in Job Sheet 7.
- Show how to work with an assistant to remove the carrier from a removable carrier housing.
- Have the students work in pairs to complete Job Sheet 7.

Objective 13H Remove, inspect, and replace a ring gear. (Job Sheet 8)

- Discuss the conditions under which the ring gear might need to be replaced.

- Show how to fix a differential case securely in a bench vise.
- Demonstrate the procedure used in Job Sheet 8.
- Have the students complete Job Sheet 8.

Objective 13I Measure differential case runout. (Job Sheet 9)

- Explain the importance of making the checks for ring gear runout and differential case runout in the correct order.
- Discuss the effect that one defective part can have on the performance and wear of other parts.
- Demonstrate the procedures used in Job Sheet 9.
- Have the students complete Job Sheet 9.

Objective 13J Remove, inspect, and replace differential side bearings. (Job Sheet 10)

- Discuss and demonstrate the procedures in Supplement 7, "Removing and Replacing Pressed-on Bearings."
- Show several types of bearing pullers and demonstrate their use.
- Show how a bearing that is still pressed on a part could be cleaned and inspected.
- Review Supplement 6, "Tapered Roller Bearing Damage Diagnosis."
- Demonstrate the procedures used in Job Sheet 10.
- Have the students use Supplements 5, 6, 7, and 8 to complete Job Sheet 10.

Objective 13K Remove, inspect, measure, adjust, and replace the parts of a conventional differential case assembly. (Job Sheet 11)

- Show the filmstrip, *The Automotive Differential*, part 3, "Overhaul."
- Display samples of worn differential case assembly parts and new parts.
- Demonstrate the procedures used in Job Sheet 11.
- Have the students complete Job Sheet 11.

Objective 13L Remove, inspect, measure, adjust, and replace limited slip differential components. (Job Sheet 12)

- Show the students a pinion gear rotator and demonstrate how to use it.
- Demonstrate how to remove the differential pinion gears without using a rotator.
- Demonstrate the procedures used in Job Sheet 12.
- Stress safety procedures for working with preload plates.
- Demonstrate one or more methods for measuring clutch pack preload.
- Have the students complete Job Sheet 12.

Objective 13M Remove and inspect a drive pinion gear assembly. (Job Sheet 13)

- Discuss the conditions under which the drive pinion gear might need to be replaced.
- Show the students examples of drive pinion gear assemblies whose parts are arranged differently than the example used in the job sheet.
- Explain what parts of the assembly will need to be replaced if the assembly is removed.
- Demonstrate the procedures outlined in Job Sheet 13.
- Have the students complete Job Sheet 13.

Objective 13N Measure and adjust drive pinion depth. (Job Sheet 14)

- Discuss the conditions under which the drive pinion depth must be measured and adjusted.
- Show the students an example of *pinion markings* on drive pinion gears. Make sure they understand the use and difference between the pinion depth marking and the gear set marking.
- Review and explain the boxed material on "Reading a Drive Pinion Depth Marking." Give the students some sample markings and have them tell what depth adjustment should be made for a drive pinion with that marking.

- Display a set of replacement depth shims and discuss how they are sized and stored.

- Demonstrate the procedures outlined in Job Sheet 14, using more than one type of drive pinion depth gauge if available.

- Have the students complete Job Sheet 14.

Objective 13O Replace drive pinion gear assembly components and measure and adjust drive pinion bearing preload. (Job Sheet 15)

- Discuss the importance of making sure that all checks and inspections have been made before beginning reassembly.

- Demonstrate the procedures outlined in Job Sheet 15.

- Have the students complete Job Sheet 15.

Objective 13P Replace and adjust the differential case assembly. (Job Sheet 16)

- Demonstrate the procedures outlined in Job Sheet 16.

- Performance of this job sheet can provide an opportunity for you to give students additional practice in adjusting ring to pinion gear backlash and ring gear tooth contact patterns.

- Have students work in pairs to complete Job Sheet 16. The replacement of a carrier on a removable carrier housing will require assistance.

Objective 13Q inspect and replace rear axle shaft wheel studs. (Job Sheet 17)

- Demonstrate the procedures outlined in Job Sheet 17.

- Have students complete Job Sheet 17.

Objective 13R Remove, inspect, and replace rear axle shaft seals and bearings. (Job Sheet 18)

- Show the video, *Automotive Seals and Bearings*, and the filmstrip, *Servicing the Axle and Differential Seals*, part 2, "Replacing the 'C' Lock type Axle Seal," and part 3, "Replacing the 'B' Type Axle Seal."

- Review the boxed material on radial lip seals contained in Objective 6.

- Review Supplement 5, "Cleaning, Inspecting, and Lubricating Antifriction Bearings," as well as Supplement 6, "Tapered Roller Bearing Damage Diagnosis Chart," and Supplement 8, "Straight Roller Bearing Damage Diagnosis Chart."

- Provide the students with additional experience in diagnosing bearing damage. Have the students pass around the room samples of damaged straight and tapered roller bearings and have each student write down their damage diagnosis of each bearing using Supplements 6 and 8.

- Demonstrate the procedures outlined in Job Sheet 18.

- Have the students complete Job Sheet 18.

Objective 13S Remove and replace axle shaft pressed-on bearings and retainers. (Job Sheet 19)

- You may want to have students complete the section in Job Sheet 21 on measuring rear axle and axle flange runout before they press new bearings and retainers on the axle shaft.

- Review Supplement 7, "Removing and Replacing Pressed-on Bearings."

- Show the students how to remove and install a pressed-on bearing using an arbor press if you did not do so when you covered Job Sheet 10. Stress safety factors related to the procedure.

- Demonstrate the procedures outlined in Job Sheet 19.

- Have the students complete Job Sheet 19.

Objective 13T Replace rear axle shafts. (Job Sheet 20)

- Show the students an example of a C-lock that fits too loosely and needs to be replaced and one that has an adequate fit.

- Provide the students with information on ordering and installing gaskets.

- Demonstrate the procedures outlined in Job Sheet 20.

- Have the students complete Job Sheet 20.

Objective 13U Measure rear axle and axle flange runout and shaft end play and complete differential and rear drive axle service. (Job Sheet 21)

- Show the students examples of a rear axle and/or axle flange that has runout and an axle shaft with excessive end play.
- Explain why some axle shaft end play is desirable.
- Point out that rear axle and axle flange runout on axles with pressed-on bearings should be checked *prior* to installing the bearings and retainers. (See Job Sheet 19.)
- Demonstrate how to make a shim for a C-lock.
- Activities in this job sheet will provide students a review of Job Sheet 1 in replacing the rear cover on an integral carrier and in refilling rear axle lubricant and Assignment Sheet 1 in test driving the vehicle to evaluate the results of service and repair.
- Demonstrate the procedures outlined in Job Sheet 21.
- Have the students complete Job Sheet 21.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.
- Evaluate the class on assignment sheet activities if this was not previously done. Provide them with copies of Supplement 1, "Making a Rear Axle/Differential Noise Diagnosis," Supplement 2, "Rear Axle Housing Lubrication Leak Diagnosis Chart," Supplement 3, "Rear Axle/Differential Noise Diagnosis Chart," and Supplement 4, "Rear Axle Differential Performance Diagnosis Chart."
- Give the practical tests. Evaluate the tests on forms provided.
- Reteach and retest as required
- Complete the appropriate section of the competency profiles.
- Review individual and group performance in order to evaluate teaching methods.
- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- Abbott, Sheldon L. *Automotive Power Trains*, 2nd ed. Encino, California: Glencoe Publishing Co., 1988.
- Anderson, James and Earl E. Tatro. *Shop Theory*, 6th ed. New York: McGraw-Hill, 1974.
- *Axle-Driveshaft Diagnosis and Service*. Detroit, Michigan: Ford Service Publications, 1978.
- "Axles—-Nomenclature and Terminology." *1989 SAE Handbook, Volume 4*. Warrendale, Pennsylvania: Society of Automotive Engineers, 1989.
- *Bearings and Seals*, 3rd ed. Moline, Illinois: Deere & Co., 1980.
- *Brakes Specialist*. Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1989.
- *Car 1987 Shop Manual—Powertrain, Lubrication, Maintenance*. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.
- *Chilton's Auto Repair Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- *Chilton's Import Car Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- Crouse, William H. and Donald L. Anglin. *The Auto Book*, 3rd ed. New York: Greg Division, McGraw-Hill, 1984.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill, 1985.
- Crouse, William H., and Donald L. Anglin. *Manual Transmissions and Power Trains*, 6th ed. New York: Gregg Division, McGraw-Hill, 1983.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.

- Erjavec, Jack. *Manual Transmissions and Transaxles.* New York City, New York: Harcourt Brace Jovanovich, Technology Publications, 1990.
- Howes, Maurice A.H., ed. *Source Book on Gear Design, Technology and Performance.* Metals Park, Ohio: American Society for Metals, 1980.
- Hughes, James G. *Guide to Automobile Certification Examination*, revised ed. Reston, Virginia: Reston Publishing Co., Inc., a Prentice-Hall company, 1983.
- *Introduction to Automotive Service.* Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1989.
- Kovacik, Robert T., and Clifford Creager. *Manual Transmissions and Drivetrains.* Cincinnati, Ohio: South-Western Publishing Co., 1984.
- Limpert, Rudolf. *Motor Vehicle Accident Reconstruction and Cause Analysis*, 2nd ed. Charlottesville, Virginia: The Michie Co., Law Publishers, 1984.
- Mitchell Information Services, Inc. *Mitchell Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- *Official ASE Preparation Guide to ASE Automobile Tests, The.* Reston, Virginia: National Institute for Automotive Service Excellence, 1989.
- *Power Trains*, 5th ed. Moline, Illinois: Deere & Co., 1984.
- *Rear Axles and Drive Shafts.* Detroit, Michigan: General Motors Corp., 1987.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1982.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.
- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1983.

- Webster, Jay. *Auto Mechanics*, 2nd ed. Encino, California: Glencoe Publishing Co., Inc., 1986.
- Webster, Jay. *Automotive Power Train Systems*. Homewood, Illinois: American Technical Publishers, Inc., 1982.
- White, John H. *Manual Transmissions and Drivetrains*. Albany, New York: Delmar Publishers Inc., 1987.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Automotive Differential, The*. 3 filmstrips, 9-13 minutes each. Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565. Basic Parts and Operation; Removal, Disassembly, and Inspection; Overhaul.
- *Automotive Information Council—Reference Center*. 13505 Dulles Technology Drive, Herndon, Virginia 22071-3415, phone (703) 904-0700. The AIC Reference Center has a reference base of over 10,000 volumes, maintaining subscriptions to over 100 trade and consumer publications relating to the automotive industry. Their computer indexing system can provide educators with up-to-date print-outs of books, articles from periodicals, statistical abstracts, press releases, catalogues, and other reference materials on 90 automotive subject classifications. AIC's services are free of charge. Copies of current articles from periodicals are also available free if requested in nominal quantities.
- *Automotive Seals and Bearings*. 10 minute video. CR Industries, 900 N. State Street, Elgin, Illinois 60120, phone 1-800-882-0008. Step-by-step procedures for removal and installation of automotive wheel seals and bearings.
- *Axle Carrier Overhaul*. 27 minute video. Dana Corporation, School Assistance Department, P.O. Box 453, Toledo, Ohio 43692-0453, phone (419) 535-4300. A service instruction on the procedure for Spicer car and light truck axle differential repairs.
- *Bearings*. 19 minutes, color 16 mm film. Lucerne Films, Inc., Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Plastic modules are used to show the principles of antifriction bearings. Special filming and photography show the ball, roller, sleeve, and needle bearings.

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- *Gears and Gear Drives.* 18 minutes, color 16 mm film. Lucerne Films, Inc., Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Gear applications are illustrated in various forms. Open and enclosed gears and gear drives are used to demonstrate their function.

- *Limited-Slip Differential, The: Pinion Operation and Service.* 10 minute video. Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565.

- *Noise, Vibration and Harshness.* 50 color slides, 58 p. Instructor Guide and 46 p. Student Text. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. The object of this text is to improve mechanical skills, to increase the accuracy of diagnosis and to provide time-saving procedures for the identification and elimination of problems relating to vehicle noise, vibration and harshness.

- *NVH Vehicle Diagnosis.* 26 minutes, color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Defines noise, vibration, and harshness concerns; provides diagnostic theory and repair procedures in step-by-step format.

- *Rear Axle Diagnosis and Overhaul.* 26 minute color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Provides complete overhaul and parts replacement procedures for integral carrier axles. Includes making and interpreting disassembly checks and inspections.

- *Rear Axle Diagnosis and Servicing.* 1 hour, 35 minutes. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Proper rear axle noise and leakage diagnosis; rear axle inspection and overhaul procedures.

- *Servicing the Axle and Differential Seals.* 3 part sound filmstrip. National Innovative Media, Route #2, Box 301B, Calhoun, Kentucky 42327, phone 1-800-962-6662, in Kentucky, (502) 273-5050. The spotlight is on lubrication and its role in the differential and drive operation. The importance of replacing seals before they become worn is an additional focus. Replacing the Differential Pinion Shaft Oil Seal; Replacing the "C" Lock type Axle Seal; Replacing the "B" Type Axle Seal.

PRETEST ANSWERS

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES *II*

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions:

Objective	Question	Objective	Question
1	1, 2	13F	19
2	3	13G	20
3	4	13H	21
4	5	13I	22
5	6	13J	23
6	7	13K	24
7	8	13L	25
8	9	13M	26
9	10	13N	27
10	11	13O	28
11	12	13P	29
12	13	13Q	30
13A	14	13R	31
13B	15	13S	32
13C	16	13T	33
13D	17	13U	34
13E	18		

ANSWER KEY

1. B
2. D
3. B
4. C
5. A
6. D
7. A
8. D
9. C
10. C
11. C
12. A
13. D
14. D
15. C
16. D
17. C
18. A
19. A
20. D
21. B
22. A
23. C
24. C
25. C
26. D
27. B
28. D
29. A
30. A
31. B
32. A
33. D
34. B

PRETEST

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

NAME ______________________________ SCORE ______

DIRECTIONS

Read the following questions and problems. Then place the letter of the item that best answers the question or solves the problem in the blank.

______1. When any one tooth of a drive gear contacts every driven gear tooth after several revolutions, the gears are called a:

A. Matched gear set
B. Hunting gear set
C. Nonhunting gear set
D. Planetary gear set

______2. In gears, the space between the sides of gear teeth when they mesh is:

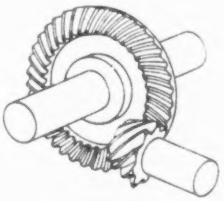
A. Clearance
B. Gear ratio
C. Preload
D. Backlash

______3. The side of a gear tooth closest to the axis is the:

A. Heel
B. Toe
C. Face
D. Flank

______4. What type of gear is shown?

A. Bevel gear
B. Spiral bevel gear
C. Hypoid gear
D. Helical gear



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______5. What type of rear drive axle housing is the most common?

A. Integral carrier
B. Removable carrier
C. Banjo carrier
D. Separable carrier

______6. Which type of antifriction bearing is most versatile in handling different weights and types of thrust loads?

A. Needle bearings
B. Ball bearings
C. Roller bearings
D. Tapered roller bearings

______7. An important design feature of a full-floating rear drive axle is:

A. The weight of the vehicle is carried by the axle housing
B. Part of the vehicle's weight is carried on the drive axle
C. It allows for smoother operation
D. It uses rear axle lubricant to help carry load stress

______8. Which of the following is **not** a function of the differential?

A. Change the direction of driveline turning power 90°
B. Divide the power between the two drive axles
C. Adjust the amount of power transmitted to each drive axle as the vehicle turns a corner
D. Allows one final gear reduction, increasing the speed and the power of the engine torque

______9. The differential side bearings operate directly between:

A. The differential side gears and the axle housing
B. The axle shaft and the differential case
C. The differential case and the axle housing
D. The differential case and the differential pinion gears

_____10. Under icy road conditions when one rear wheel is on ice and one is not, a limited-slip differential will:

A. Provide most of the turning power to the wheel on the ice
B. Provide most of the turning power to the wheel off the ice
C. Divide the turning power evenly between both wheels
D. Increase the turning power to both wheels

_____11. In a limited-slip differential, pressure is kept on the clutch plates by:

A. Clutch disc shims
B. Antifriction bearings
C. Preload springs
D. A collapsible spacer

_____12. A ring gear tooth contact test can identify the need for which of the following differential adjustments?

A. Backlash
B. Preload
C. Runout
D. Both A and C

_____13. During a diagnostic road test, there is a groaning noise which continues even when the vehicle is put in reverse. What is the most probable cause?

A. Bad drive pinion bearing
B. Ring and pinion gear backlash
C. Worn thrust washers
D. Wrong rear axle lubricant

_____14. How often should rear axle lubricant be changed?

A. As often as the manufacturer recommends
B. At least every 25,000 miles
C. At least every 50,000 miles
D. Both A and B

_____15. What is the part called that holds the axle shafts in place in an integral carrier housing?

A. Differential shaft lock bolt
B. Retainer ring
C. C-lock
D. Preload spring

_____16. What is the cause of ring gear runout?

A. Warped ring gear
B. Loose ring gear bolts
C. Worn differential side gears
D. Both A and B

_____17. Technician A says that a ring gear tooth contact pattern should be made before the differential case is removed. Technician B says a ring gear tooth contact pattern should be made after the differential case is reinstalled after being removed. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____18. What tool is used to check ring to pinion gear backlash?

A. Dial indicator
B. Feeler gauge
C. Torque wrench
D. Inside micrometer

_____19. If very little torque is needed to rotate the drive pinion gear, what is the probable cause?

A. There is little or no preload on the drive pinion bearing
B. The drive pinion gear depth is not set correctly
C. The drive pinion bearing is operating correctly
D. The drive pinion shim is the wrong width

_____20. Which of the following checks should be made before removing the differential case from the axle housing?

A. Ring gear tooth contact patterns
B. Ring gear runout
C. Ring gear backlash
D. All of the above

_____21. Technician A says the ring gear should always be removed before removing the differential pinion and side gears. Technician B says that the ring gear only needs to be removed if it is damaged or if there is ring gear runout. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____22. The differential case runout is not within specifications. Technician A says that the differential case should be replaced. Technician B says that the ring gear should be replaced to see if that will correct the differential case runout. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____23. Technician A says it is important to wash and dry antifriction bearings in order to detect damage. Technician B says you should avoid removing antifriction bearings for cleaning because they are often damaged when they are removed. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____24. Which of the following is **not** considered a part of the differential case assembly?

A. Side gear
B. Pinion gear
C. Drive pinion gear
D. Pinion shaft

_____25. What is the purpose of the deep grooves machined into the sides of limited-slip cones?

A. To seat them in the differential case
B. To allow the proper preload setting
C. To allow for the flow of rear axle lubricant
D. To allow the differential to "slip" when one drive wheel loses traction

_____26. If the drive pinion gear is damaged:

A. Both the drive pinion and the ring gear should be replaced
B. Only the drive pinion should be replaced
C. The axle housing should be checked for foreign material
D. Both A and C

_____27. If a drive pinion gear has a plus sign (+) and a number on it, the service specialist, when adjusting the drive pinion depth, will know to:

A. Add shims to the drive pinion depth setting
B. Subtract shims from the drive pinion depth setting
C. Measure the depth shim to make sure it conforms to this width
D. Set the drive pinion depth at this number

_____28. The preload on drive pinion bearings is set by using:

A. Washers
B. Adjusting nuts
C. Preload plates
D. A collapsible spacer

_____29. When replacing the differential case, Technician A says that the gear teeth on the ring gear and drive pinion gear must always be rematched in their original position. Technician B says this is only necessary if the gears are a nonhunting gear set. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____30. Technician A says that the wheel studs on the axle flange should be replaced when they are loose or damaged. Technician B says that they should be replaced whenever the rear axle has been serviced or repaired. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____31. Technician A says it doesn't matter which side of the oil seal faces the lubricant. Technician B is careful to install rear axle oil seals with the inside face toward the lubricant. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____32. Axle bearings are held on the axle shaft by:

A. Bearing retainers
B. Preload plates
C. Bearing bolts
D. Backing plates

_____33. Axles are held securely in place by:

A. Retainer plates
B. C-locks
C. Splines
D. Both A and B

_____34. The movement of an axle shaft in and out of the axle housing is called:

A. Axle shaft runout
B. Axle shaft end play
C. Axle shaft backlash
D. Axle shaft thrust

INFORMATION SHEET

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 1

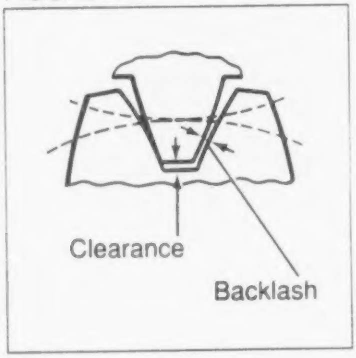
Choose the correct definitions for terms associated with the automotive differential and rear drive axles by selecting the correct definition from four choices.

axis — A center line (often imaginary) around which a part such as a gear rotates

backlash — In gears, the space between the pitch lines (sides) of two meshing gear teeth (Figure 1)

EXAMPLE:

FIGURE 1



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chamfer — A beveled edge, often including a groove

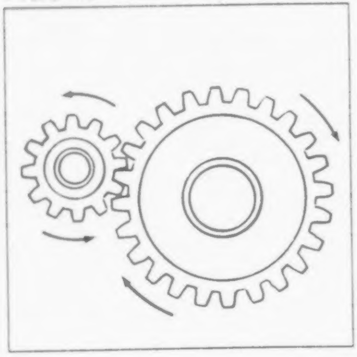
clearance — In gears, the space between the bottom of one gear tooth and the valley between the two gear teeth with which the tooth meshes

drive gear — The gear in a gear set that moves first and causes the other gears to move

driven gear — A gear that is moved by another gear (Figure 2)

EXAMPLE:

FIGURE 2



gear ratio — A numerical ratio representing the number of turns made by the drive gear to complete one turn of the driven gear

NOTE: To calculate the gear ratio of a pair of gears, divide the number of teeth on the driven gear by the number of teeth on the drive gear.

EXAMPLE: The drive gear has 12 teeth, the driven gear has 24. Divide the number of teeth on the driven gear (24) by the number of teeth on the drive gear (12).

$$\begin{array}{r} 2 \\ 12\overline{)\,24} \\ \underline{24} \end{array}$$

The gear ratio is 2.00:1. The last number in an automotive gear ratio is always *one*, indicating *one* turn of the driven gear.

gear set — Two or more meshing gears

hunting gear set — Any one tooth of the drive gear contacts every driven gear tooth after several revolutions. Gear contact patterns are consistent on every gear tooth in the gear set.

EXAMPLE: Gear ratio of 3.42:1

matched gear set code — A code stamped on each gear in a gear set which enables the gears to be properly matched

mesh — In gears, the proper working contact of gear teeth in a gear set

nonhunting gear set — Any one tooth of the drive gear contacts only certain driven gear teeth during several revolutions. Gear contact patterns are **not** consistent on every gear tooth in the gear set.

EXAMPLE: Gear ratio of 3.00:1

To determine if a gear set is a hunting or a nonhunting gear set, divide the number of teeth on the smaller gear into the number of teeth on the larger gear. If the result is a whole number rather than a decimal (or fraction), the gear set is a **nonhunting** gear set.

pinion gear — The smaller or smallest gear in a gear set

preload — In bearings, preload is the pressure placed on the bearing before the bearing is put under actual operating conditions. Correct preload assures that the bearing is held in the correct position tightly enough to function properly.

press fit — Two parts that fit together so tightly that special (often hydraulic) tools are required to force them together or apart

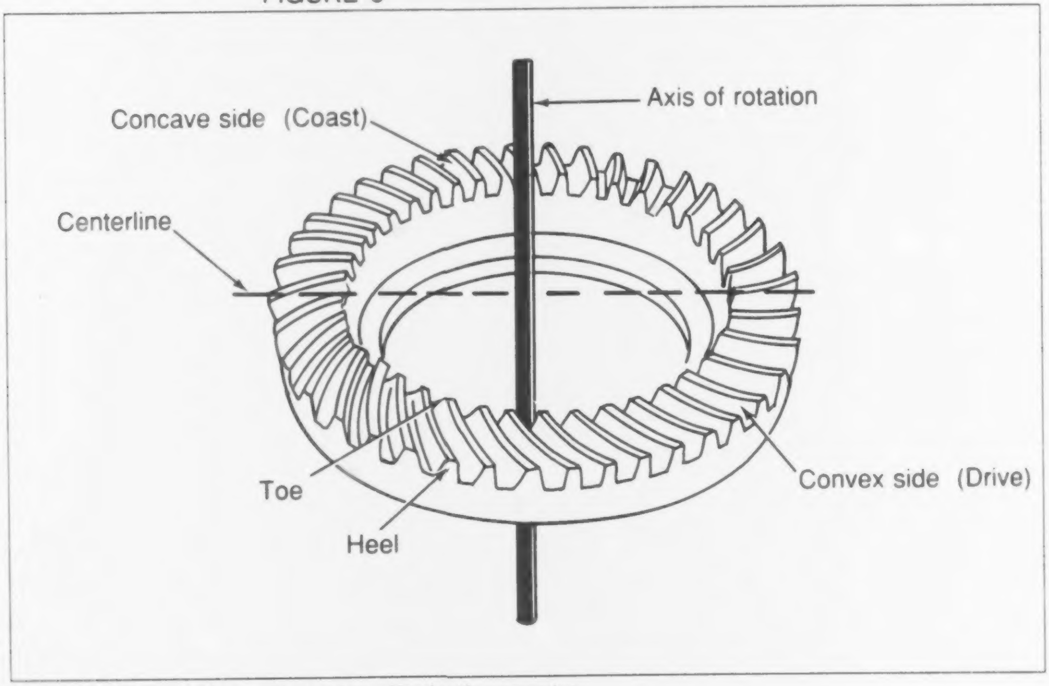
ring gear — The larger or largest gear in a gear set. Also a gear cut on a ring-shaped rim

specifications — Information (such as measurements, standards, or procedures) provided by a vehicle's manufacturer which should be applied to that vehicle to assure that the vehicle operates properly

OBJECTIVE 2 **Match the names of the parts of a gear and a gear tooth to illustrations.**

PARTS OF A GEAR

FIGURE 3


Axis of rotation
Concave side (Coast)
Centerline
Toe
Heel
Convex side (Drive)

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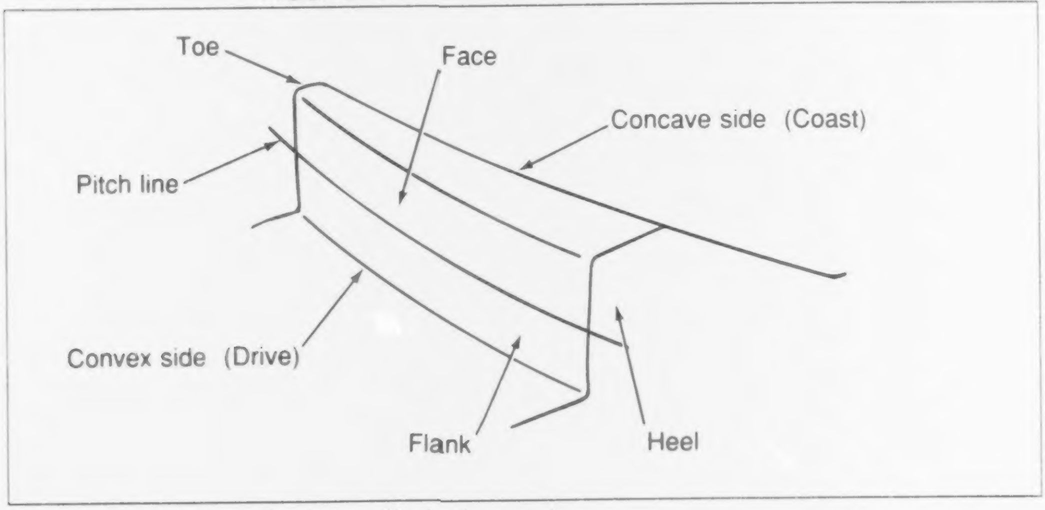
PARTS OF A GEAR TOOTH

FIGURE 4


Toe
Face
Concave side (Coast)
Pitch line
Convex side (Drive)
Flank
Heel

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OBJECTIVE 3 **Match the names of common gear types with illustrations of the gears.**

GEARS THAT OPERATE ON PARALLEL SHAFTS

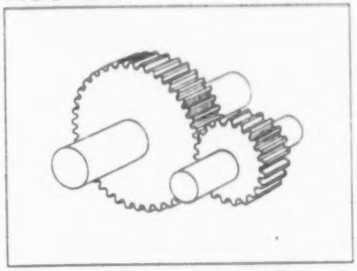
Spur Gears — Cylindrical in shape, the gear's straight teeth are always parallel to the gear axis (Figure 5)

Simplest gear shape, noisy, usually used only for slow speed transfer

EXAMPLE: Reverse gear in transmission

EXAMPLE:

FIGURE 5



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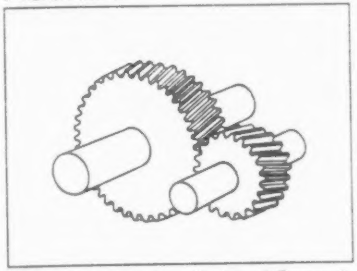
Helical Gears — Cylindrical in shape, the gear's straight teeth are set at an angle across the gear's surface (Figure 6)

Angular contact makes for greater strength and quieter operation

EXAMPLE: Most transmission gears

EXAMPLE:

FIGURE 6



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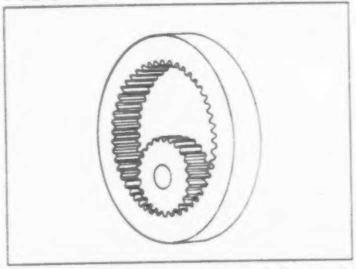
Internal Gears — Cylindrical in shape, the gear's teeth can either be set straight or helical (Figure 7)

Allow for compact transfer involving a number of speed changes

EXAMPLE: Planetary gears in transmissions

EXAMPLE:

FIGURE 7



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GEARS THAT OPERATE ON NONPARALLEL, INTERSECTING SHAFTS

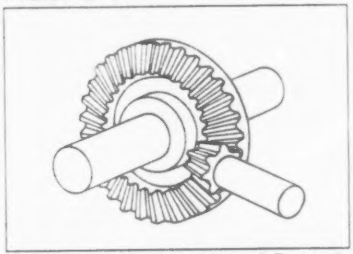
Straight Bevel Gears — Conical in shape, the gear has straight teeth aligned so they point toward the gear axis (Figure 8)

Allow for change in direction of torque during transfer

EXAMPLE: Differential side gears

EXAMPLE:

FIGURE 8



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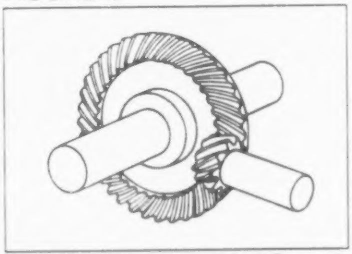
Spiral Bevel Gears — Conical in shape, the gear has curved teeth set at an angle across the gear's tooth surface (Figure 9)

Angular tooth contact makes for greater strength and quieter operation

EXAMPLE: Drive pinion gear on older model vehicles or modern trucks

EXAMPLE:

FIGURE 9



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GEARS THAT OPERATE ON NONPARALLEL, NON-INTERSECTING SHAFTS

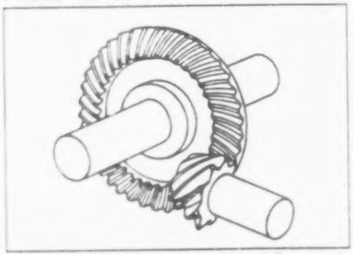
Hypoid Gears — Conical in shape, the gear usually has spiral teeth (Figure 10)

Non-intersecting shafts allow the drive pinion to be placed much lower on the ring gear, lowering driveline tunnel

EXAMPLE: Drive pinion & ring gear

EXAMPLE:

FIGURE 10



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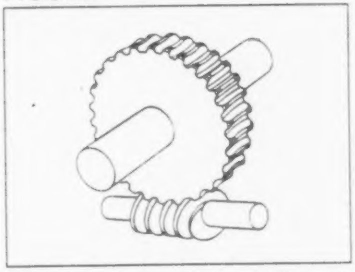
Worm Gears — Usually cylindrical in shape, the teeth of one or both gears in a set are machined in the form of a screw (Figure 11)

Sometimes used in steering mechanisms

EXAMPLE: Speedometer gear on transmission output shaft

EXAMPLE:

FIGURE 11



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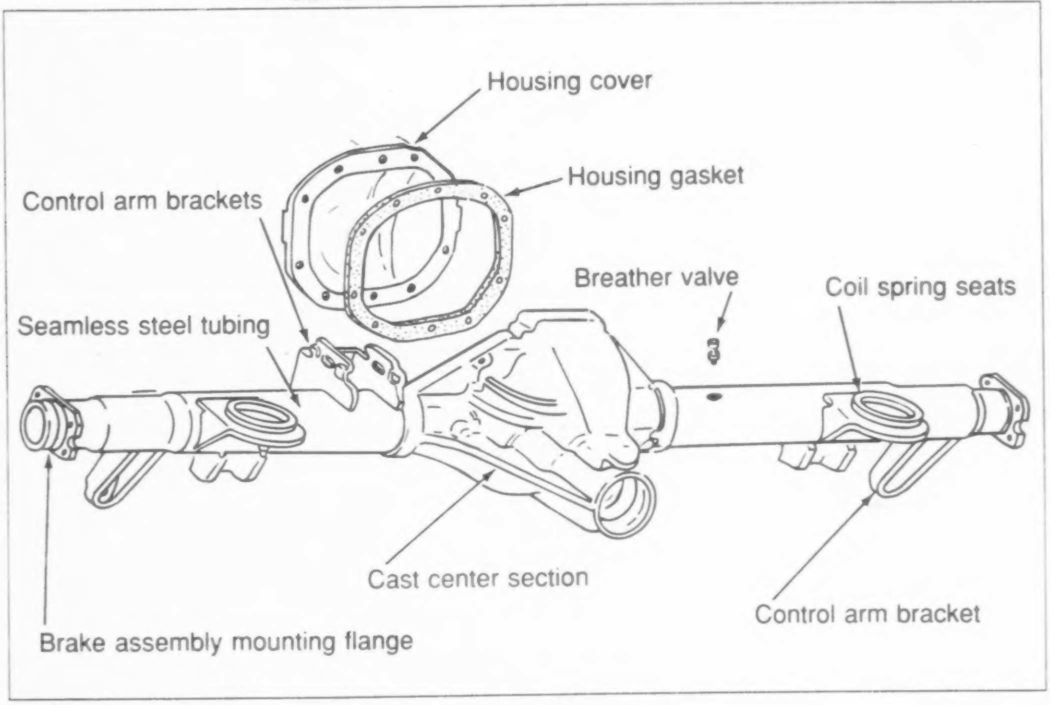
OBJECTIVE 4

Label illustrations of the two types of rear axle housings with their correct names.

NOTE: The differential and drive axles in a rear-wheel drive vehicle operate inside a **rear axle housing**. The rear axle housing is sometimes called a ***differential carrier*** or simply a ***carrier***. (Often an automotive specialist may refer to the rear axle housing as an *axle housing* when he is working on or near the axles and a *differential housing* when he is working on or near the differential.) Both types of housings shown here commonly have fill holes with plugs for adding rear axle lubricant, a small vent for equalizing air pressure, and design features which allow the housing to be attached to the vehicle's suspension.

INTEGRAL CARRIER

FIGURE 12


Housing cover
Housing gasket
Control arm brackets
Breather valve
Coil spring seats
Seamless steel tubing
Cast center section
Control arm bracket
Brake assembly mounting flange

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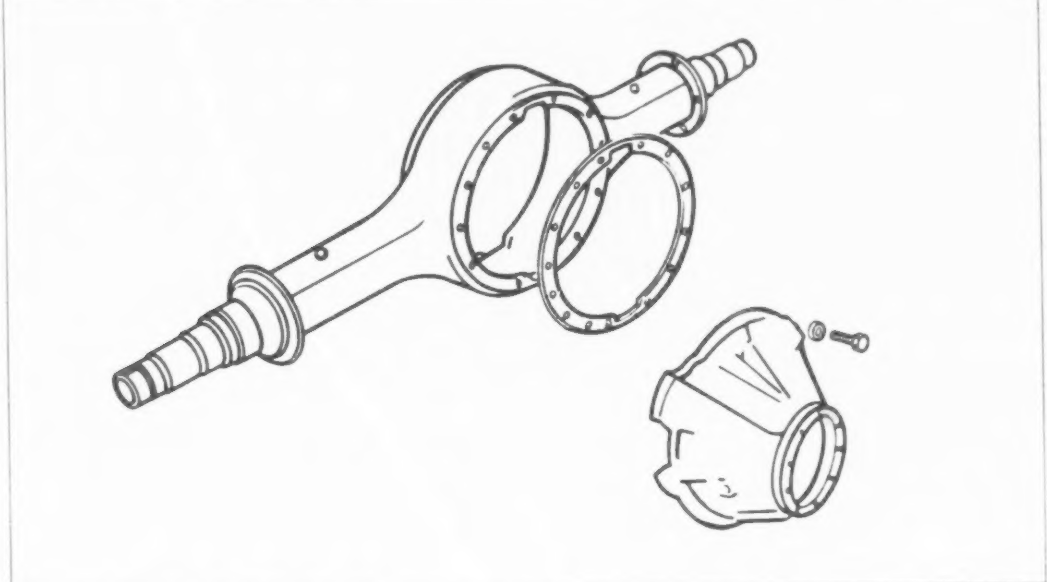
NOTE: Also called a ***unitized carrier housing***, an integral carrier is the most common type of rear axle housing. The housing cover on an integral carrier opens to the rear of the vehicle. The service technician must work on the differential in this type of axle housing while it is in the vehicle. If the differential needs to be removed, it must be dismantled and removed part by part.

REMOVABLE CARRIER

FIGURE 13



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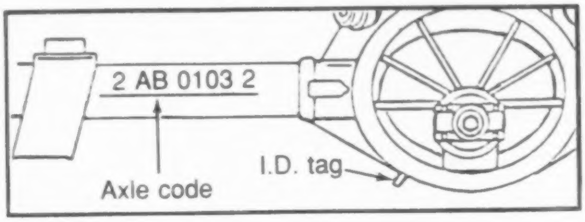
NOTE: Also called a ***separable carrier housing*** or a ***banjo housing***, a removable carrier housing opens to the front of the vehicle. If the differential requires service, the carrier is removed from the axle housing as a unit, and the service specialist works on the differential inside the carrier at a workbench rather than on the vehicle.

DIFFERENTIAL IDENTIFICATION CODE

Before working on a differential or drive axle, the technician must know the type and size of the differential, and the differential gear ratios. The easiest way to locate this information is to first locate the differential identification code stamped on the rear axle housing. This code may be stamped on the front of the rear axle housing or on a metal tag attached to the housing's cover bolts or fill plug. Sometimes the differential identification code is with the vehicle's identification number by the windshield or on the driver's door. Once the code has been located, use it with the vehicle's service manual to identify specifications relevant to the differential and drive axle.



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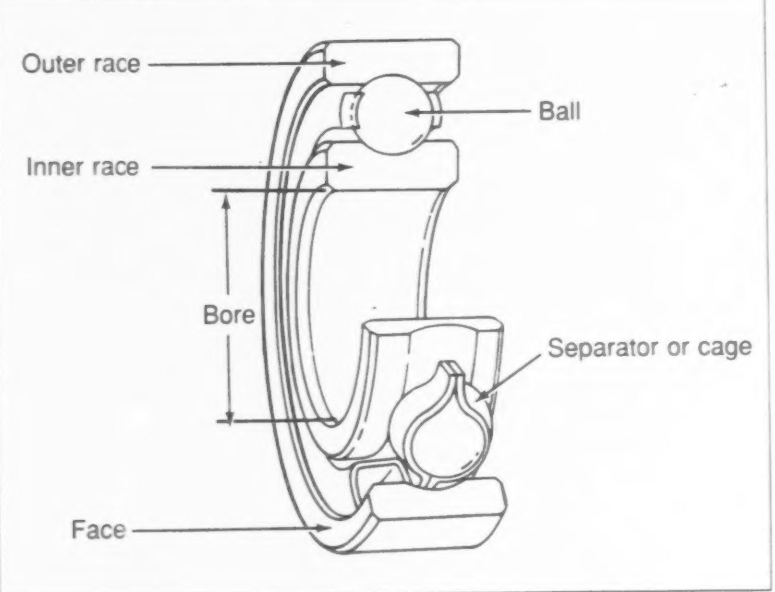
OBJECTIVE 5

Label three types of antifriction bearings and match the names of their parts to illustrations.

BALL BEARINGS

FIGURE 14


Outer race
Ball
Inner race
Bore
Separator or cage
Face

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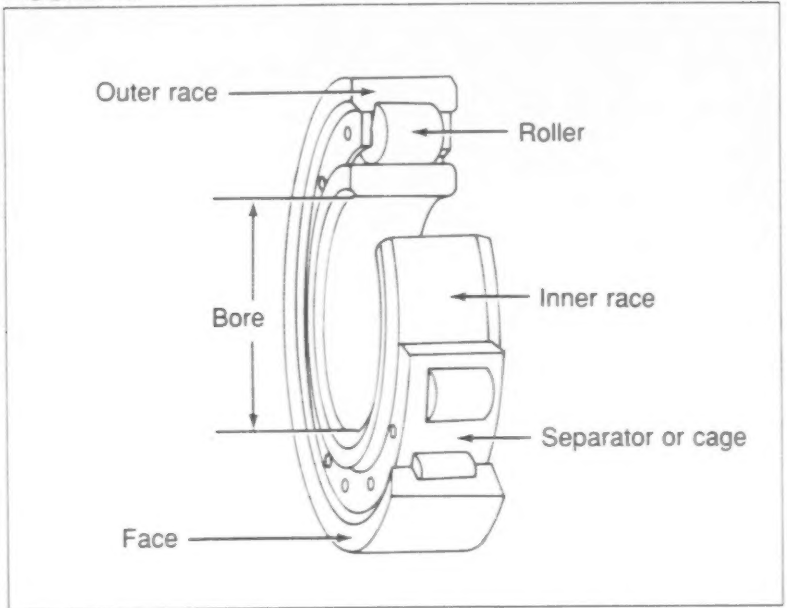
NOTE: ***Ball bearings*** can handle heavy radial and moderate thrust loads. They are used on rear drive axles of lighter weight vehicles.

STRAIGHT ROLLER BEARING

FIGURE 15


Outer race
Roller
Bore
Inner race
Separator or cage
Face

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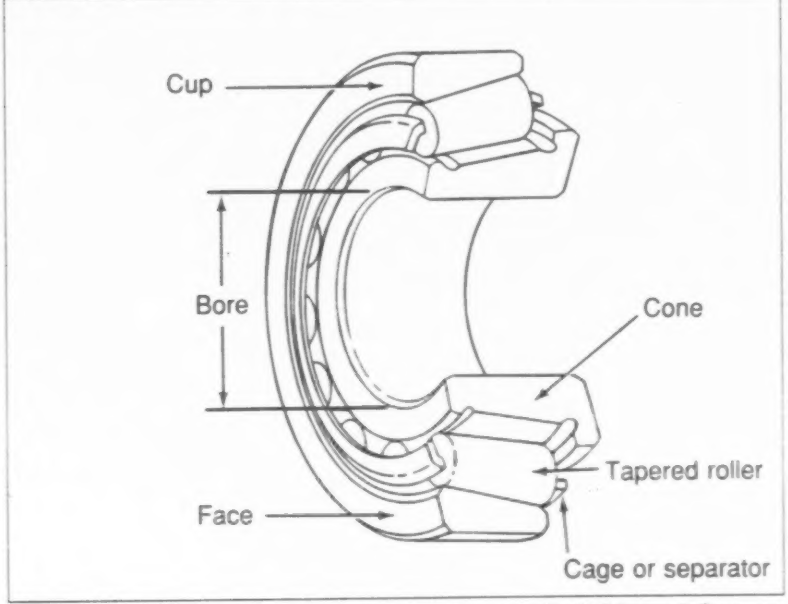
NOTE: ***Straight roller bearings*** can handle heavy radial loads but little or no thrust load. They are used on most rear drive axles of medium and heavier weight vehicles.

TAPERED ROLLER BEARING

FIGURE 16



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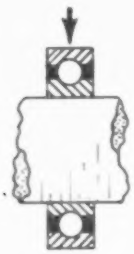
NOTE: ***Tapered roller bearings*** can handle both heavy radial and heavy thrust loads. They are used on front axles, full-floating rear axles, differential side bearings, and drive pinion assemblies.

BEARING IDENTIFICATION

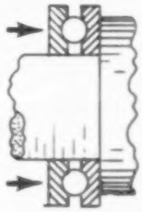
A part number is located on the face of every bearing and should be referenced if the bearing needs to be replaced. Always replace the entire bearing assembly if any single part is defective.

BEARING LOAD

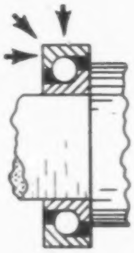
Antifriction bearings are designed to reduce friction between two parts which move in relation to each other. As it does this job, weight or force is almost always applied to the bearing assembly while it operates. This force (represented here by arrows) takes one of three forms:



RADIAL LOAD



THRUST LOAD



COMBINATION RADIAL AND THRUST LOAD

The type of bearing selected for a job is chosen on the basis of the type of load the bearing must handle and the weight or force of that load.

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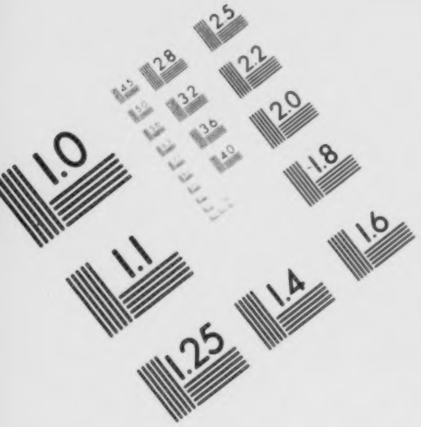
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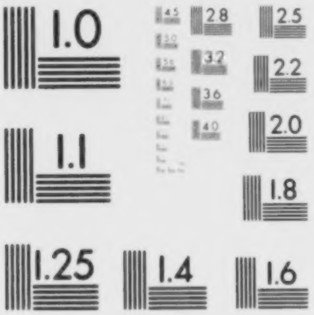
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5

Centimeter
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
mm
1
2
3
4
5
Inches


1.0
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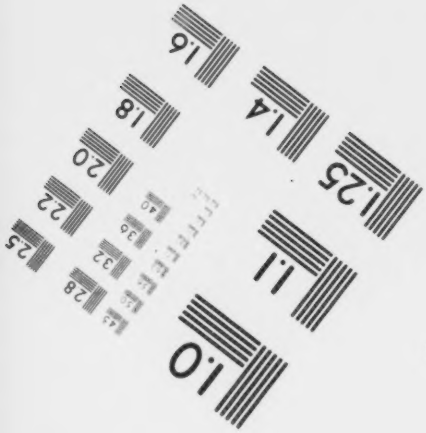
4.0
4.5


1.0
1.1
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2.0
2.2
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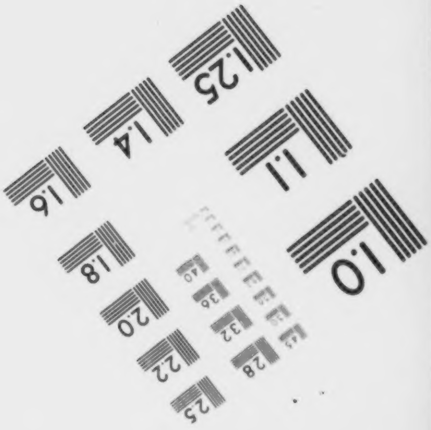
2.8
3.2
3.6
4.0
4.5


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5

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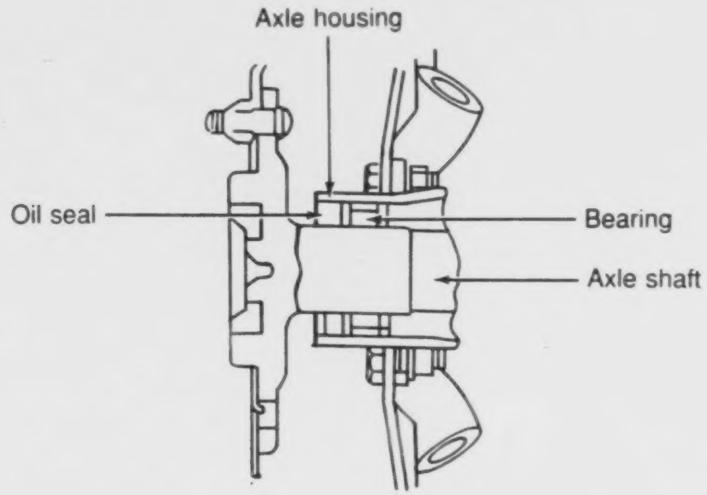
OBJECTIVE 6 **Label the two types of rear drive axles and their parts on illustrations.**

SEMI-FLOATING AXLE

FIGURE 17



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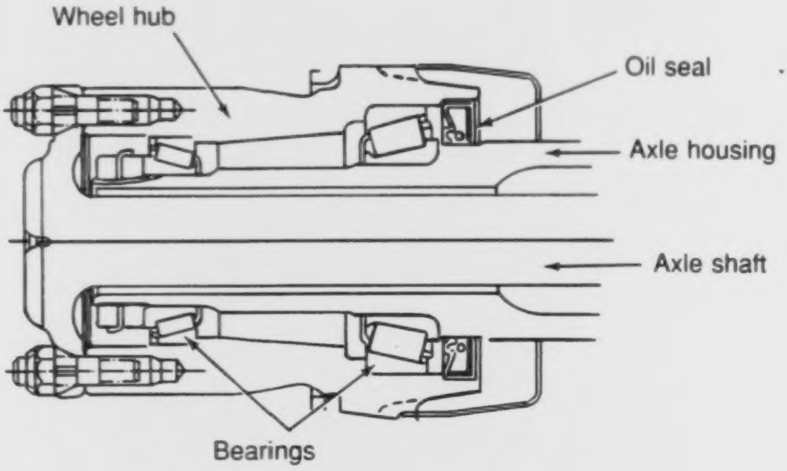
NOTE: Most rear-wheel drive automobiles use a ***semi-floating axle*** made of hardened steel which is splined to the differential side gear and supported by the differential on its inside end. The outer end is bolted to the wheel hub. A semi-floating axle uses a single bearing near the hub between the axle and the axle housing. The bearing assembly around the axle not only allows the smooth rotation of the axle, but supports part of the weight of the vehicle as well.

FULL-FLOATING AXLE

FIGURE 18



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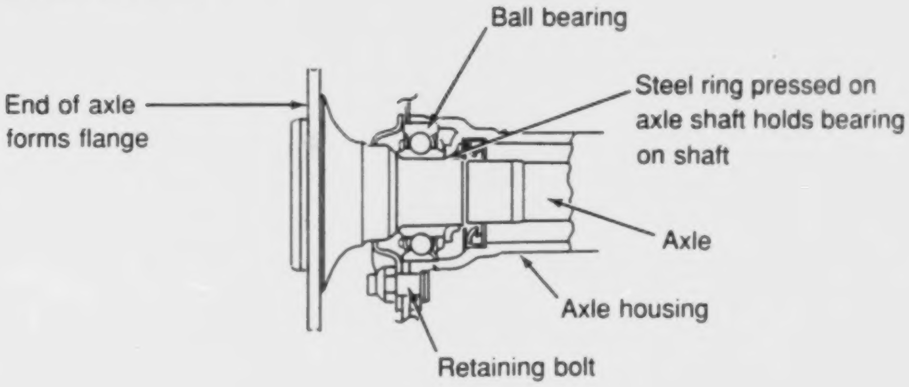
NOTE: The axles of heavier vehicles such as trucks and vans cannot support the weight placed on them by a semi-floating axle design. ***Full-floating axles*** used on these vehicles are splined to the differential side gear on the inside, but the outside end of the axle is bolted to a wheel hub which fits over the end of the axle housing. Two bearings placed between the wheel hub and the axle housing on either side of the wheel centerline allow smooth rotation. The axle rotates the wheel, but the *weight* of the vehicle is carried totally by the axle housing.

AXLE PARTS

Depending on their particular design, both types of axles can use seals, gaskets, shims, and bearing retainers to complete their assembly. Axle bearings can be ball bearings, roller bearings, or tapered roller bearings and are lubricated by either bearing grease or differential lubricant. If the bearing is lubricated by differential lubricant, the seal is placed on the wheel side of the bearing to keep the lubricant from leaking out the hub. If bearing grease is used, the seal is on the side of the bearing away from the wheel—to keep the differential lubricant from diluting and washing away the bearing grease.

TYPES OF AXLE ENDS

Flanged Axle End


Ball bearing
End of axle forms flange
Steel ring pressed on axle shaft holds bearing on shaft
Axle
Axle housing
Retaining bolt

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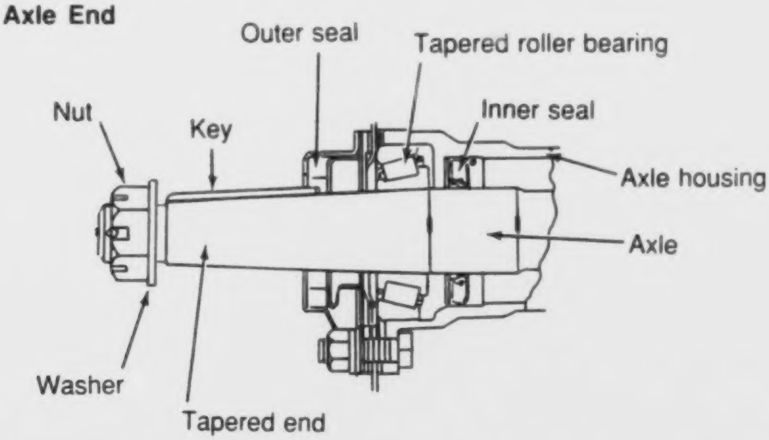
NOTE: Flanged axles are the most common type of axle end.

Tapered Axle End


Outer seal
Tapered roller bearing
Nut
Key
Inner seal
Axle housing
Axle
Washer
Tapered end

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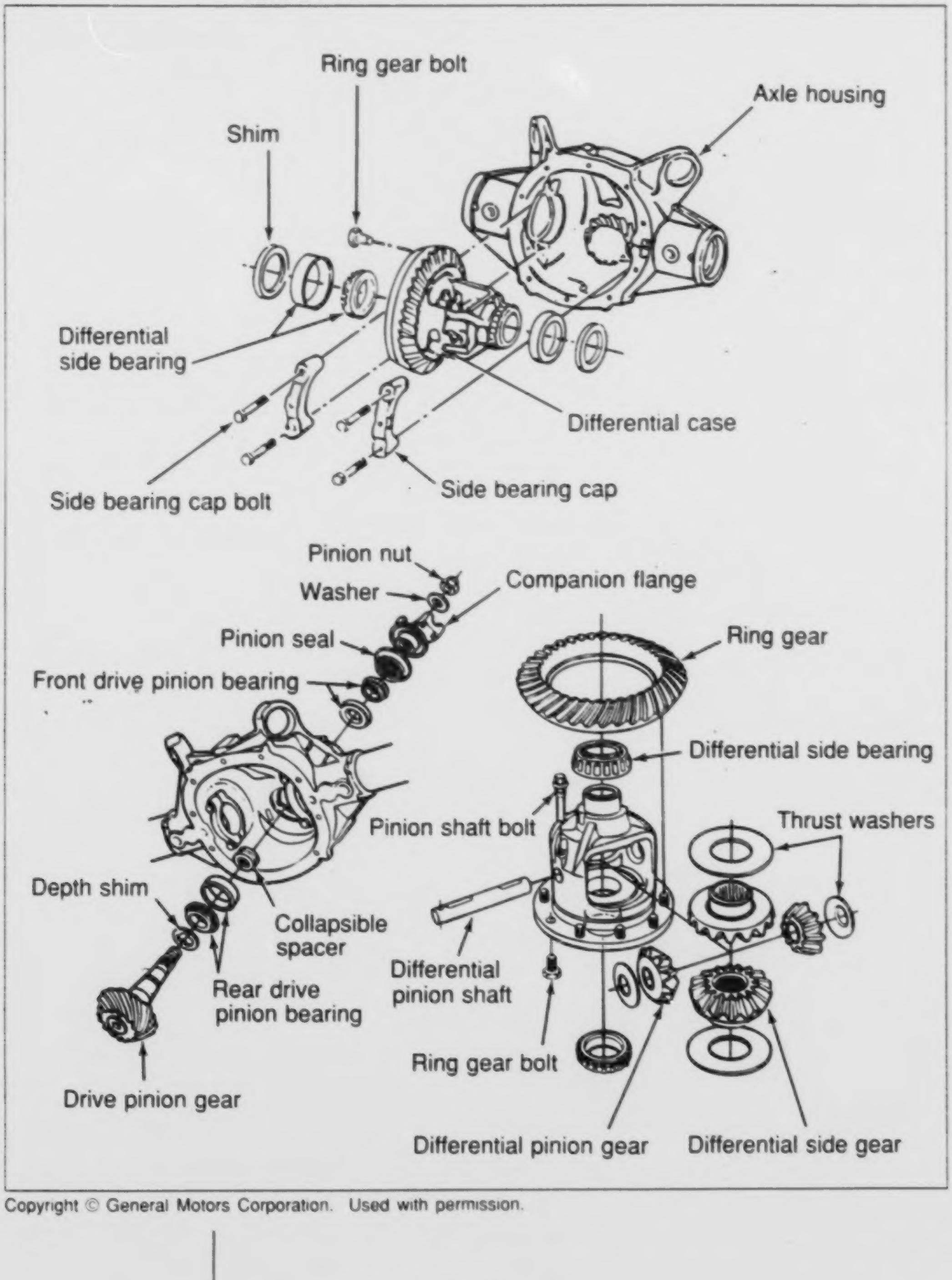
OBJECTIVE 7

Write the four functions of a differential.

- Changes the direction of driveline turning power 90°
- Divides the power between the two drive axles
- Adjusts the amount of power transmitted to each drive axle as the vehicle turns a corner
- Allows one final gear reduction, reducing the *speed* and increasing the *power* of the engine torque

OBJECTIVE 8 **Match the names of the parts of a conventional differential to an illustration.**

FIGURE 19


Ring gear bolt
Axle housing
Shim
Differential side bearing
Differential case
Side bearing cap bolt
Side bearing cap
Pinion nut
Washer
Companion flange
Pinion seal
Ring gear
Front drive pinion bearing
Differential side bearing
Pinion shaft bolt
Thrust washers
Depth shim
Collapsible spacer
Differential pinion shaft
Rear drive pinion bearing
Ring gear bolt
Drive pinion gear
Differential pinion gear
Differential side gear

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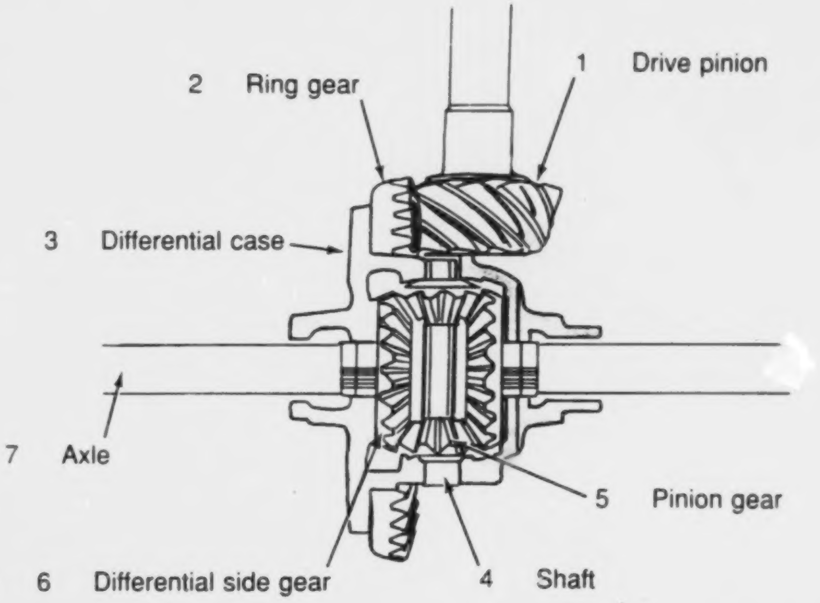
POWER FLOW IN A CONVENTIONAL DIFFERENTIAL


1 Drive pinion
2 Ring gear
3 Differential case
7 Axle
5 Pinion gear
6 Differential side gear
4 Shaft

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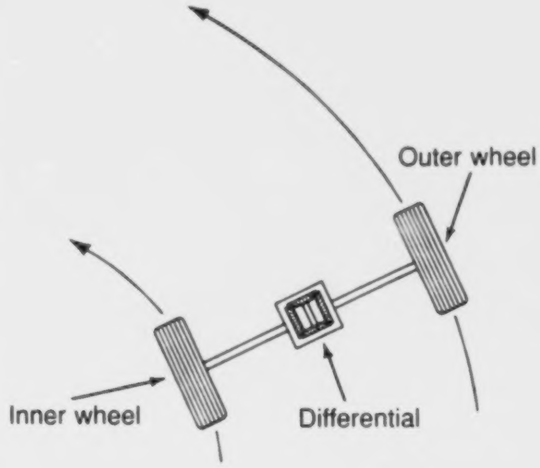
NOTE: The parts are numbered in the order in which they receive the power flow.

ADJUSTING POWER FLOW TO TURN A CORNER



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When a vehicle is moving in a straight line, although every other differential component is rotating on its axis, the two differential pinion gears and the differential pinion shaft are not. They are turning end over end as the differential pinion shaft is rotated by the differential case, but they are not rotating on their axes.

Simple ***resistance*** is the force that adjusts the power flow delivered to the two drive axles. When the vehicle is turned, the inner wheel *resists* turning more than the outer wheel. This resistance makes the differential side gear on that axle harder to turn than the side gear on the outer axle. This difference in resistance between the side gears makes the pinon gears start to rotate.

Because turning power always seeks the path of least resistance, the differential pinion gears will turn the side gear that is *easier* to turn faster than it will the other side gear. In this case, the side gear on the axle of the outside wheel will get more power—simply because it is easier to turn. The pinion gears continue to deliver more power to the side gear with the less resistant axle *until the resistance is equal.* The action of the pinion gear *splits* the power between the two axles. How much power each axle gets depends on how resistant it is to the force the pinion gears are applying.

This principle does not just apply to vehicles that are turning. If a vehicle were moving in a straight line with one drive wheel on a dirt surface and the other on wet ice, the wheel on ice would receive more turning power—just because it would be easier to turn.

OBJECTIVE 9

Distinguish between the functional operation of a conventional and a limited-slip differential.

Under conditions where a vehicle's two drive wheels have significantly different traction (when, for example, one wheel is on ice), a conventional differential will provide most or all available turning power to the wheel with the **least** amount of traction. A limited-slip differential will divide the power evenly. There is no difference in the way the two types of differentials operate under normal driving conditions.

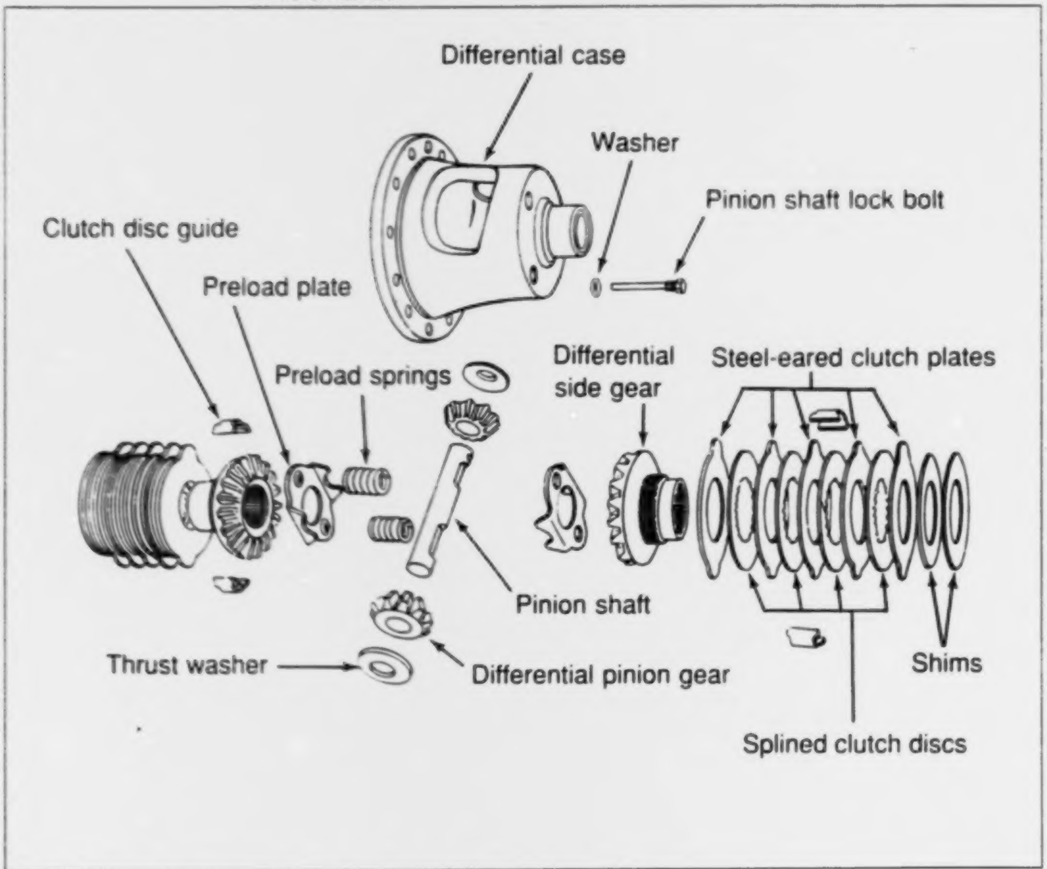
NOTE: A limited-slip differential, in addition to having the components present in a conventional differential, has ***clutch discs or cones*** made of hardened steel with textured friction surfaces. During normal driving and cornering these clutch surfaces slip, presenting no obstruction to the differential's operation. However when one drive wheel proves much more difficult to turn than the other, the clutch or cone engages, forcing the power to both drive axles equally. Although limited-slip differentials are used extensively in rear-wheel-drive vehicles, conventional differentials are still more commonly found.

OBJECTIVE 10 **Label two main types of limited-slip differentials and match the names of their parts to illustrations.**

NOTE: On the surface it appears that there are many different "types" of limited-slip differentials because they go by so many different names. Actually there are only two main categories of limited-slip differentials—the numerous different "types" are actually brand names used by different manufacturers.

CLUTCH PLATE TYPE LIMITED-SLIP DIFFERENTIAL

FIGURE 20


Differential case
Washer
Pinion shaft lock bolt
Clutch disc guide
Preload plate
Preload springs
Differential side gear
Steel-eared clutch plates
Pinion shaft
Thrust washer
Differential pinion gear
Shims
Splined clutch discs

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EXAMPLE:

FIGURE 21

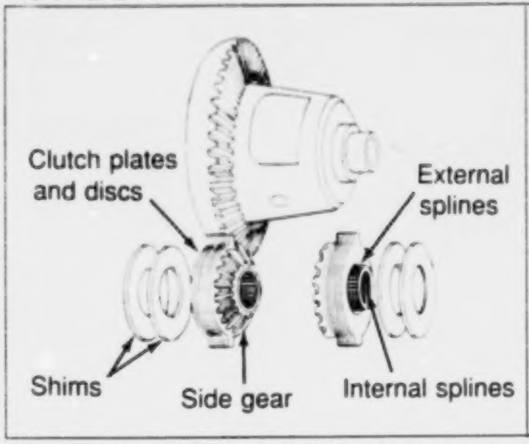
Clutch plates and discs
External splines
Shims
Side gear
Internal splines

FIGURE 22

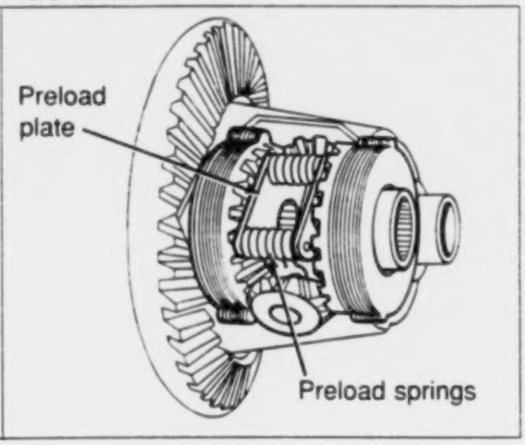
Preload plate
Preload springs

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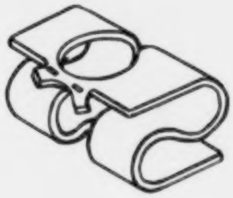
FIGURE 23

NOTE: An S-shaped spring placed over the pinion shaft often replaces the preload plate and springs in late model vehicles.



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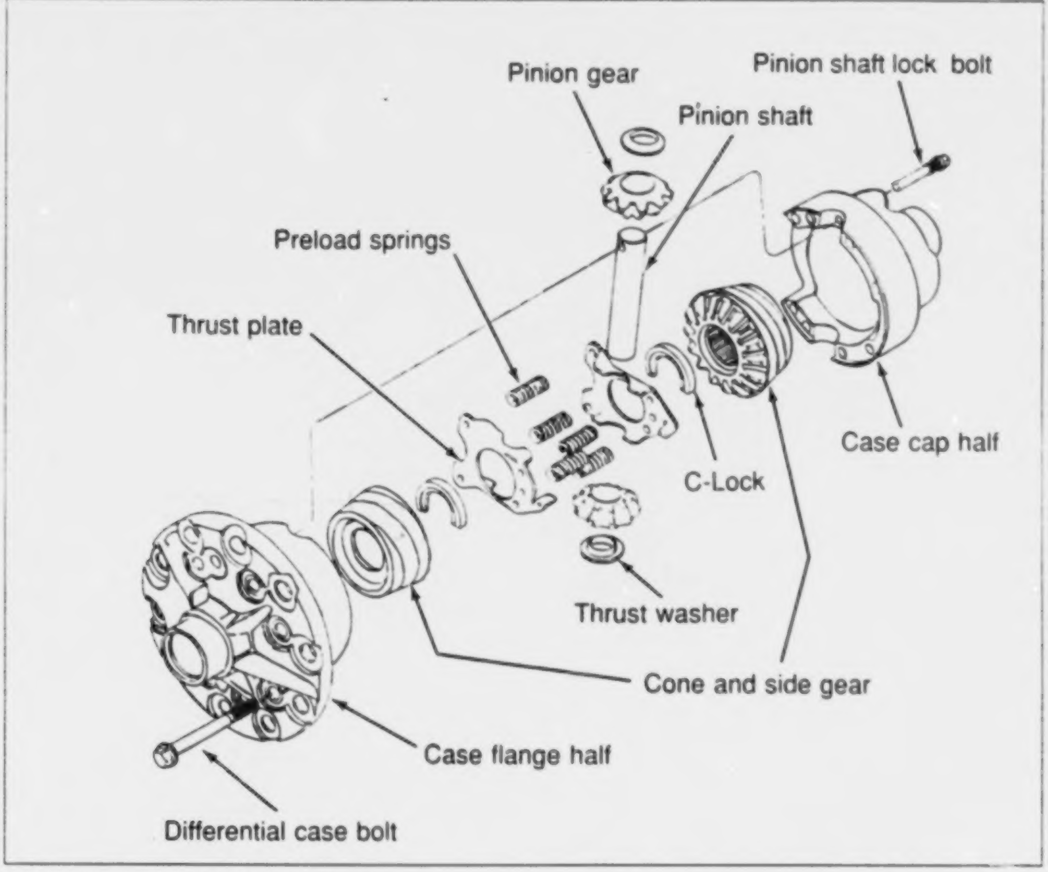
CONE TYPE
LIMITED-SLIP DIFFERENTIAL

FIGURE 24


Pinion gear
Pinion shaft lock bolt
Pinion shaft
Preload springs
Thrust plate
Case cap half
C-Lock
Thrust washer
Cone and side gear
Case flange half
Differential case bolt

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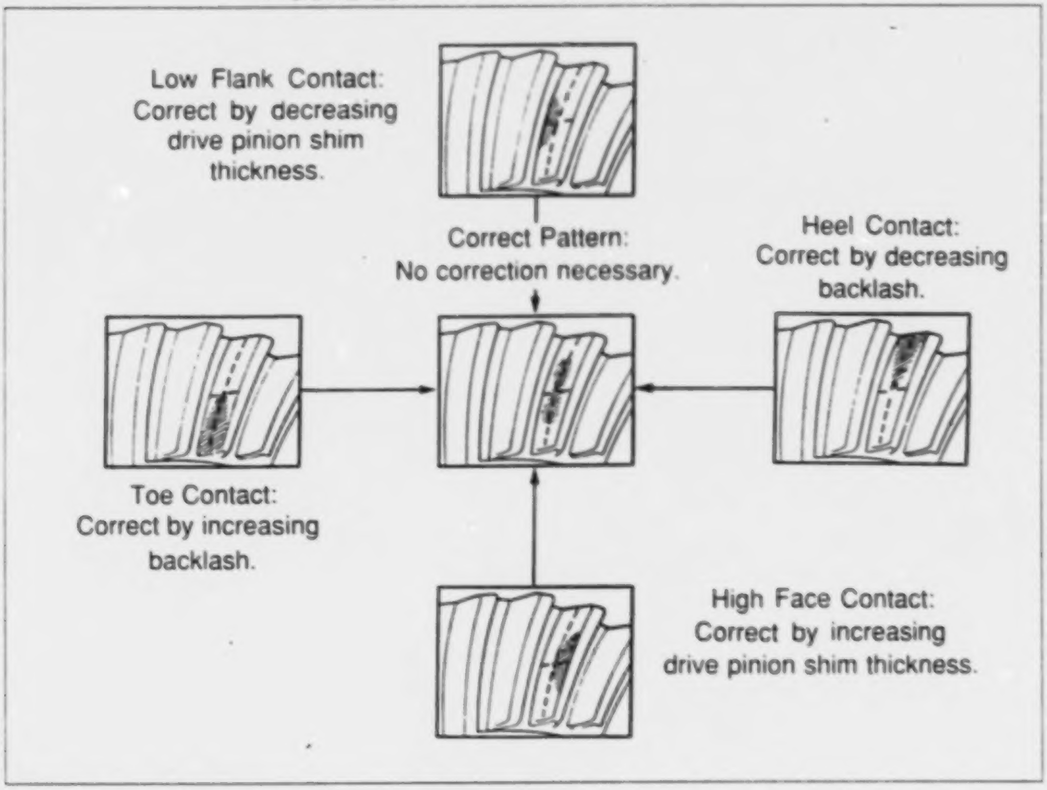
NOTE: The deep grooves machined into the cone and side gears allow the rear axle lubricant free access to all parts of this assembly.

OBJECTIVE 11 | **Determine needed differential adjustments by examining illustrations of ring gear tooth contact patterns.**

RING GEAR TOOTH CONTACT PATTERN DIAGNOSIS CHART

FIGURE 25


Low Flank Contact: Correct by decreasing drive pinion shim thickness.
Correct Pattern: No correction necessary.
Heel Contact: Correct by decreasing backlash.
Toe Contact: Correct by increasing backlash.
High Face Contact: Correct by increasing drive pinion shim thickness.

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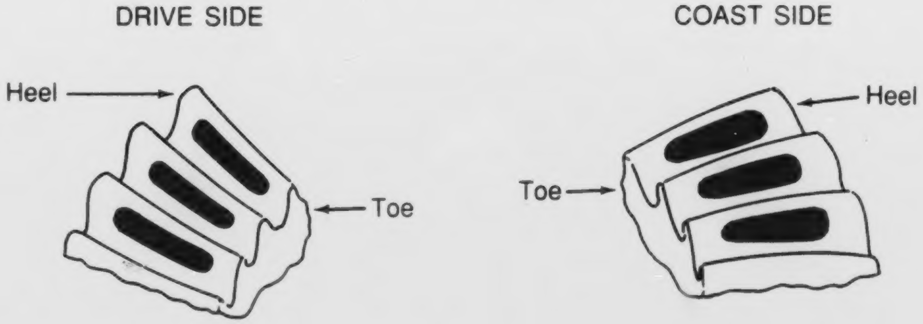
GEAR TOOTH CONTACT PATTERNS

When the ring gear and the drive pinion gear mesh during operation, the surfaces of the gear teeth meet. Because the drive pinion gear applies heavy pressure to the ring gear while it turns it, pressure patterns, usually known as ***tooth contact patterns***, are left on the gear teeth. By looking at these pressure patterns on the ring gear, the technician can diagnose needed adjustments to the differential.

Correct Ring Gear Tooth Contact Patterns



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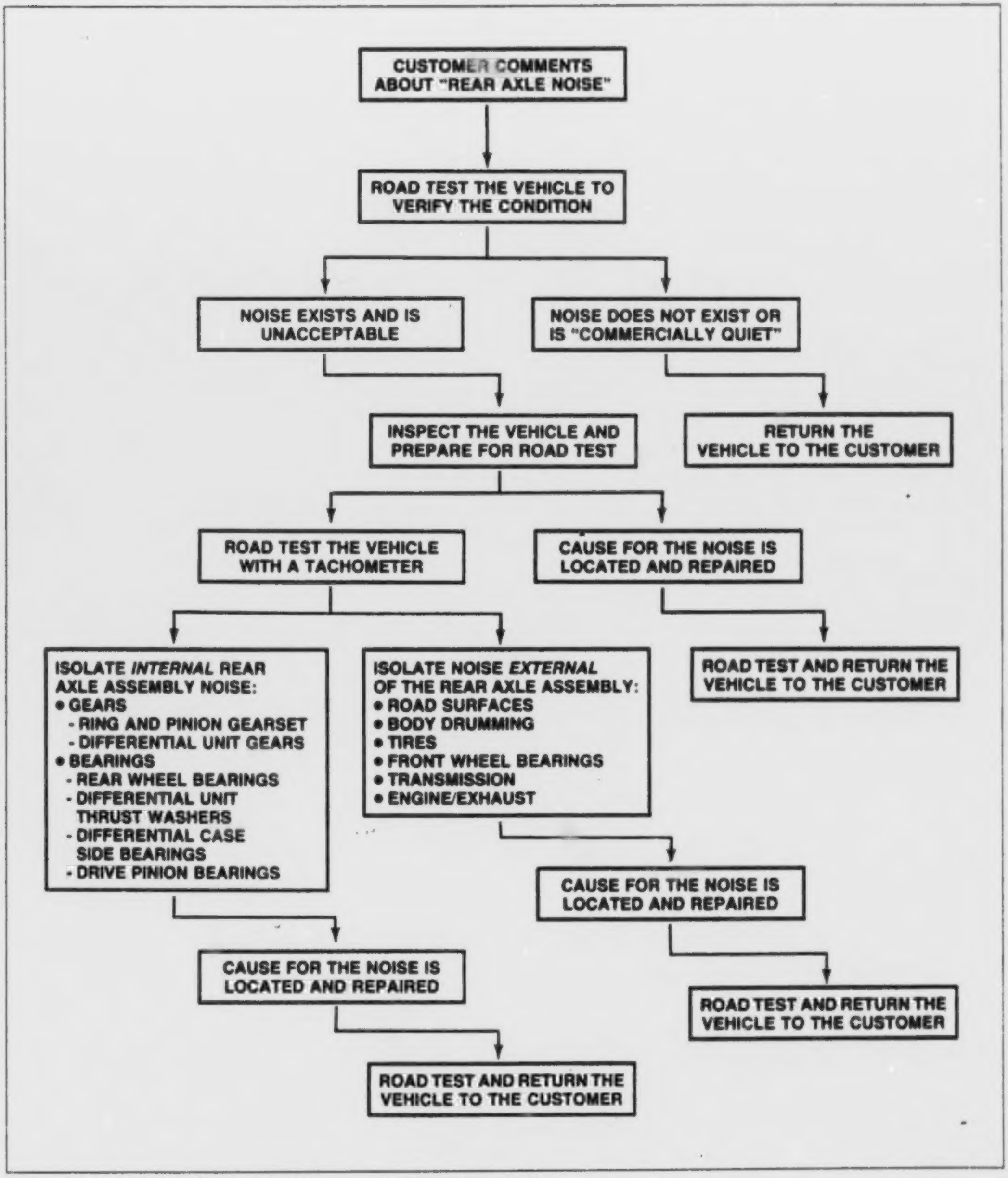
When examining the tooth contact patterns, always look at the patterns on the drive side of the gear tooth. Notice that the pattern should be towards the center of the gear tooth, not on the edge.

NOTE: The tooth contact patterns shown are for a ring gear operating under a light load. This is the type of pattern seen when a ring gear tooth contact pattern test is made. If the patterns were taken under normal driving conditions, the area of contact would be much larger on the drive side face of the tooth—extending almost to the edges of the tooth. The contact area would be much larger because under normal driving conditions much greater power would be transmitted between the two gears.

MAKING A REAR AXLE/DIFFERENTIAL NOISE DIAGNOSIS

FIGURE 1


CUSTOMER COMMENTS ABOUT "REAR AXLE NOISE"
ROAD TEST THE VEHICLE TO VERIFY THE CONDITION
NOISE EXISTS AND IS UNACCEPTABLE
NOISE DOES NOT EXIST OR IS "COMMERCIALLY QUIET"
INSPECT THE VEHICLE AND PREPARE FOR ROAD TEST
RETURN THE VEHICLE TO THE CUSTOMER
ROAD TEST THE VEHICLE WITH A TACHOMETER
CAUSE FOR THE NOISE IS LOCATED AND REPAIRED
ISOLATE INTERNAL REAR AXLE ASSEMBLY NOISE:
• GEARS
- RING AND PINION GEARSET
- DIFFERENTIAL UNIT GEARS
• BEARINGS
- REAR WHEEL BEARINGS
- DIFFERENTIAL UNIT THRUST WASHERS
- DIFFERENTIAL CASE SIDE BEARINGS
- DRIVE PINION BEARINGS
ISOLATE NOISE EXTERNAL OF THE REAR AXLE ASSEMBLY:
• ROAD SURFACES
• BODY DRUMMING
• TIRES
• FRONT WHEEL BEARINGS
• TRANSMISSION
• ENGINE/EXHAUST
ROAD TEST AND RETURN THE VEHICLE TO THE CUSTOMER
CAUSE FOR THE NOISE IS LOCATED AND REPAIRED
CAUSE FOR THE NOISE IS LOCATED AND REPAIRED
ROAD TEST AND RETURN THE VEHICLE TO THE CUSTOMER
ROAD TEST AND RETURN THE VEHICLE TO THE CUSTOMER

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MAKING A REAR AXLE/DIFFERENTIAL NOISE DIAGNOSIS (CONTINUED)

1. TALK TO THE VEHICLE'S OWNER.

The first step in diagnosing any automotive problem is to talk to the vehicle's owner about the nature of the problem. Review Supplement 3, Unit 1 for general guidelines for "Making a Diagnostic Road Test."

2. ROAD TEST THE VEHICLE TO VERIFY THE CONDITION.

- Many noises reported as coming from the rear axle assembly actually originate from other sources:
  - Road surfaces
  - Body drumming
  - Transmission
  - Tires
  - Front wheel bearings
  - Engine and exhaust system
- Rear axle gears, like any other mechanical device, are not absolutely quiet and should be accepted as being commercially quiet unless some abnormal noise is present. "Commercially quiet" means that the noise level matches that of other identical vehicles which are operating as designed. This means that there are different noise levels for the different models of passenger cars and light-duty trucks, all of which are "commercially quiet." Identical rear axles in different vehicles will produce different noise levels.
- Be sure there is enough rear axle lubricant to drive the vehicle. Inspect for fluid loss.

3. RAISE THE VEHICLE AND INSPECT IT.

- Check the rear axle lubricant for the correct level.
- Inspect the axle housing for rear axle lubricant leaks (See Supplement 2.) Check for leaks due to casting porosity as well as leaks near oil seals, housing gaskets, and welds.
- Check the exhaust system to see if any components are too close and are rubbing against the frame or underbody.
- Check for metal-to-metal contact between the rear springs and frame. Also inspect rear control arm bushings for abnormal contact with the axle housing or frame.

- Rotate the front wheel bearings and check for rough operation and looseness.
- With the transmission in neutral, rotate each rear wheel by hand and listen near the hub for wheel or axle noise.
- Temporarily inflate all tires to approximately 50 pounds pressure for test purposes. This will change noise caused by tires but will not affect rear axle noise.
- Install a tachometer in the passenger compartment for use during the next road test.

4. ROAD TEST THE VEHICLE WITH A TACHOMETER.

- Select a level, smooth asphalt road to reduce any noise from tires and body drumming.
- Listen for tire noise which is constant and more pronounced between 20 and 30 mph.
- Lightly apply the brakes to diminish front wheel bearing noise.
- Change transmission speeds while holding vehicle speed constant. This will make engine and transmission noises more pronounced.
- Vary engine speed to make engine and exhaust system noises more pronounced.
- Note the engine speed at which the noise occurs. With the engine running, vehicle stopped, and transmission in neutral, duplicate the engine speed and listen for noise. Noises that are heard only with the vehicle stopped are probably caused by the engine, exhaust system, clutch, transmission, or accessories.
- Listen for these internally-caused rear axle/differential noises:
    - — Ring and pinion gear set whine, audible from 20 to 55 mph under "drive," "road load," "float," and "coast" driving conditions

      NOTE: Gear noise (whine) is audible from 20 to 55 mph under four driving conditions:

        - Drive—Acceleration or heavy pull
        - Road Load—Car driving load at constant speed

- Float—Using enough throttle to keep the car from driving the engine—car slows gradually but engine still pulls slightly
- Coast—Throttle closed and car in gear. Gear noise most frequently has periods where noise is more prominent, usually 30 to 40 mph and 50 to 55 mph.

— Differential pinion, side bearing, and side gear noise, while turning

— Rear wheel bearing growl, which continues in "coast" at low speed (transmission in neutral)

— Differential side bearing growl, which does not vary in "drive" and "coast"

— Drive pinion inner and outer bearing noise, which is louder during "drive" and "coast"

5. **LOCATE THE CAUSE OF THE REAR AXLE/ DIFFERENTIAL NOISE.**

- Use the ring gear tooth contact pattern test (Job Sheet 4) and backlash check (Job Sheet 5) for locating ring and pinion gear set whine or driveline "clunk."

- Use Supplements 6 and 8, "Tapered & Straight Roller Bearing Damage Diagnosis Charts," to help with diagnosis of bearing noises.

- Use the differential pinion-to-side gear backlash check (Job Sheet 11) to locate noise while turning.

REAR AXLE HOUSING LEAK DIAGNOSIS CHART

LOCATION OF LEAK	POSSIBLE CAUSES	CORRECTIVE ACTION
DRIVE PINION OIL SEAL	Improper seal installation	Install replacement seal
	Worn/damaged seal lip	Install replacement seal
	Improper seal bore machining	Inspect and measure seal bore. If surface cannot be repaired, replace the housing or carrier
	Improper companion flange machining	Inspect and measure edge of flange. If surface cannot be repaired, replace the flange
DRIVE PINION NUT	Leakage past threads	Remove pinion nut, clean pinion nut threads with solvent, and apply a bead of sealer at threads and mating surfaces; install a coated replacement nut, and torque to specifications
HOUSING COVER BOLTS	Leakage past threads	Remove the bolt and apply sealer to the inside threads; torque to specifications
CARRIER OR HOUSING COVER GASKET	Worn/damaged gasket	Inspect the mating surfaces for damage and replace the gasket or sealant; use new lock nuts and washers
CARRIER BOLTS	Leakage past threads	Remove nuts and washers and clean area with solvent; inspect surfaces. Install new lock nuts and washers and torque to specifications

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REAR AXLE HOUSING LEAK DIAGNOSIS CHART (CONTINUED)

LOCATION OF LEAK	POSSIBLE CAUSES	CORRECTIVE ACTION
AXLE SHAFT OIL SEAL	Improper seal installation	Install replacement seal
	Worn/damaged seal	Install replacement seal
	Improper seal bore machining	Inspect and measure seal bore—if surface cannot be repaired, replace the axle housing
	Improper axle shaft	Inspect axle shaft surface—machining if machining exists that will damage seal, replace the axle shaft
VENT	Lubricant overfilled	Remove lubricant
	Vent out of position	Correct position
	Hose crimped or broken	Repair or replace
JIGGLE CAP VENT	Worn/damaged vent	Replace vent
REMOTE VENT	Clogged vent	Remove vent assembly, plug hole and steam clean area. Install cleaned vent and new hose assembly
WELD OR AXLE HOUSING	Broken weld	Replace axle housing
	Weld or casting porosity	Peen porous area full of body lead and finish with epoxy sealer

REAR AXLE/DIFFERENTIAL NOISE DIAGNOSIS CHART

Causes that are more probable are listed first.

NOISE	POSSIBLE CAUSE
Loud clunk in driveline when shifting from reverse to forward	Driveline universal joint Differential case Drive axles
Groan in forward or reverse	Wrong rear axle lubricant
Clunking during acceleration or deceleration	Ring and pinion gear backlash Worn differential pinion shaft Worn differential case Differential side gear hub counterbore worn oversize Insufficient lubrication on driveline slip joint Worn differential pinion and side gear teeth Worn thrust washers Ring and pinion gear backlash
Knock at low speed	Worn universal joint Driveline universal joint Differential side gear hub counterbore worn oversize
Continuous low whirring noise starting at low speed	Drive pinion bearing
Continuous knocking	Ring and pinion gear damage Loose or displaced ring gear bolts
Knocking noise on rough road conditions	Axle shaft end play
Growling noise in drive or coast mode	Drive pinion bearing
Chuckle during coast	Worn differential pinion gears Ring and pinion gear damage
Knock or click at approximately every two revolutions of rear wheel	Driveline universal joint Rear axle bearing

REAR AXLE/DIFFERENTIAL NOISE DIAGNOSIS CHART (CONTINUED)

NOISE	POSSIBLE CAUSE
Noise is same in all driving modes	Road noise Tire noise Front wheel bearing Drive pinion bearing Axle bearing Axle shaft surface finish Low rear axle lubricant level
Continuous growling at all speeds	Drive pinion bearing Differential side bearing
Howling or whining noise in drive, coast, or float modes—all gears	Ring and pinion gears Low rear axle lubricant level
Bearing noise—whining or whistling directly related to vehicle speed	Drive pinion bearing Wheel bearing Axle bearing
Bearing rumble	Wheel bearing
Whining noise on corners and curves	Damaged differential pinion gears Damaged differential pinion shaft
Rough growling when turning corners	Wheel or axle bearing
Chatter and vibration on corners	Wrong lubricant in limited slip differential Worn limited-slip clutch plates Thrust washers Excessive differential side bearing preloading
Noise most pronounced on turns	Limited-slip clutches Differential pinion gears Differential side gears
Chuckling when slowing down or stopping	Excessive ring and pinion backlash Ring and pinion gear tooth damage

COMMON VEHICLE NOISES

Chatter — a rapid "click-click-click" that creates vibration

Chuckle — resembles the sound of a stick laid against the spoke of a spinning bicycle wheel

Click — a slight noise

Clunk — a sharp, loud noise of one part hitting another—usually felt as well as heard

Groan — a low moaning sound

Growl — a low, harsh sound

Howl — a very loud, continuous sound, like a dog howling

Knock — a sharp pounding sound like someone rapping on a door

Rumble — a low, rolling sound, like the sound of distant thunder, or marbles in a box

Whine — a continuous high-pitched "wheee" sound

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REAR AXLE/DIFFERENTIAL PERFORMANCE DIAGNOSIS CHART

Causes that are more probable are listed first.

PROBLEM	POSSIBLE CAUSE
Vibration	Tires Universal joint Unbalanced or damaged driveshaft Improper driveline angle Companion flange runout Rough rear wheel bearings Axle shaft/housing
Inoperative drive axle	Broken axle shaft Broken welds Wheel bearing Differential lockup Broken gear teeth in differential
Limited-slip not working on slippery surfaces	Limited slip clutches
Differential not working freely during turns	Drive pinion bearings Ring and pinion gears
Broken differential case	Incorrect side bearing preload Incorrect ring and pinion backlash Vehicle overloaded Erratic clutch operation
Broken differential side gear	Misaligned axle housing Worn thrust washers Excessive housing deflection
Broken rear axle	Incorrect axle bearing adjustment Misaligned axle housing Vehicle overloaded Clutch grabs
Broken ring and pinion gear teeth	Vehicle overloaded Erratic clutch operation Normal fatigue Incorrect ring and pinion backlash

CLEANING, INSPECTING, AND LUBRICATING ANTIFRICTION BEARINGS

Many antifriction bearings are joined to other parts such as an axle housing or a drive pinion shaft in a **press fit**—they fit together so tightly that special (often hydraulic) tools are required to force them together or apart.

Such bearings must be removed with a bearing puller or an arbor press and they are often damaged in the process. Bearings are a precision assembly and even the slightest damage—twisting or indentation that is almost impossible to see—can make them worse than useless, since they are capable of damaging other parts that are dependent on their proper functioning. For this reason, the Drivetrain and Axles Specialist should try to clean and inspect a pressed-on bearing **without** removing it from the component to which it is pressed. Sometimes, of course, this is not possible.

Before antifriction bearings can be inspected, they must be thoroughly clean and dry so that imperfections indicating damage and wear can be easily seen. If inspection shows that the bearing can be reused, it will need to be relubricated with the appropriate lubricant or repacked with bearing grease before it can be replaced for use. Whether the bearing is to be relubricated or repacked with grease depends upon how and where the bearing is used. It is important to check the vehicle's service manual to determine the appropriate method of relubricating each bearing.

NOTE: Because bearings operate in high stress situations, even a very small particle of dust or dirt can damage them. It is important that the procedures for washing and lubricating the bearings be carried out in a very clean environment and that after washing and lubrication they be wrapped in lint-free shop towels or similar protective covering until they are installed.

How to Clean Antifriction Bearings

NOTE: Do not wash bearings which are factory packed and sealed on both sides. To clean such bearings before inspection, wipe with a lint-free shop towel.

1. Use a shop towel to wipe excess grease off each bearing assembly.

2. Soak each assembly in an approved cleaning solvent, taking care not to mix sets.

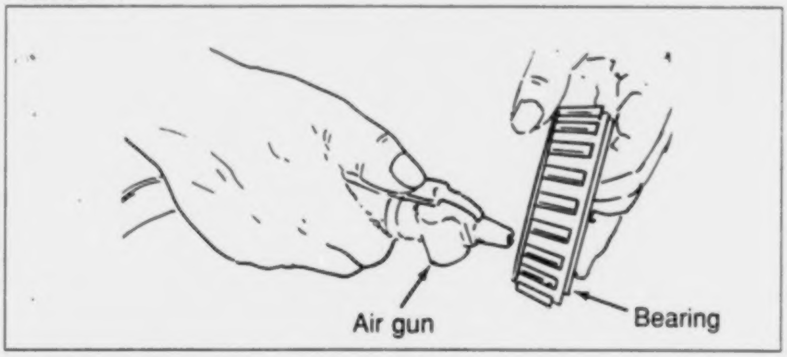
◆ WARNING ◆

Always use a solvent recommended by the vehicle manufacturer. **Never** use gasoline or any other volatile liquid as a cleaning solvent. Such liquids are fire hazards and can be harmful to the skin and eyes.

3. After they have soaked, scrub each assembly with a bristle brush until the assembly is clean.

4. Use a low-pressure air nozzle to blow out any remaining dirt particles and solvent from each assembly. (Figure 1)

FIGURE 1



Adapted with permission of The Timken Company.

CAUTION

Do **not** spin the rollers with compressed air. Spinning may damage the rollers or the inside race or cause the assembly to fly apart with violent force. This is *extremely* dangerous.

5. When you are sure the bearing is clean, rinse it in a container of clean solvent.

6. Blow the bearing dry and reassemble it.

7. Work a very small amount of bearing grease into the bearing, rotating it to spread a thin coat throughout the bearing.

How to Inspect Antifriction Bearings

1. Rotate the bearing by hand; if it feels rough or stops, discard it.

2. Use a bright light and a magnifying glass to examine the bearing races for the following:

   - Cracks in the race or separator
   - Dents or nicks on the race or separator
   - Flaked metal
   - Rust or corrosion
   - Discoloration—indicates overheating

   NOTE: Some bearings are made of a black oxide material. In such bearings the color on the bearing is even throughout. This coloration is normal.

4. Examine the bearings or bearing rollers for damage, using Supplement 6, "Tapered Roller Bearing Damage Diagnosis Chart," or Supplement 8, "Straight Roller Bearing Damage Diagnosis."

5. If the bearing has *even the slightest* damage as shown by any of the above conditions, discard the bearing and replace it.

6. If the bearing can be reused, consult the vehicle's service manual to determine the correct lubricant for the bearing.

How to Relubricate Antifriction Bearings with Rear Axle Lubricant

1. Pour a small amount of lubricant into the bearing and rotate the bearing gently to distribute a light coating of lubricant throughout the bearing.

2. Bearings using rear axle lubricant should be filled to the center of the lowest ball or roller on the bearing.

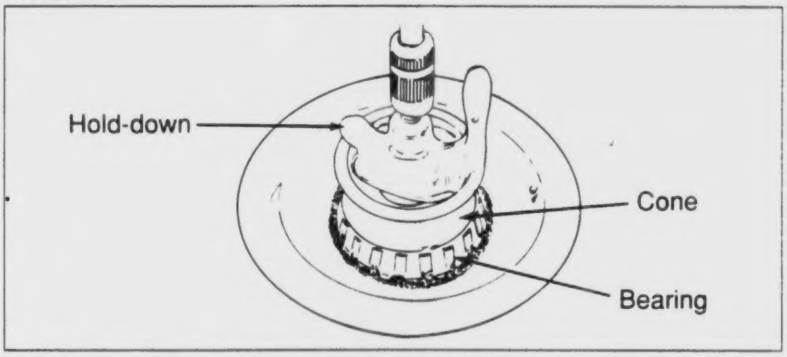
   NOTE: Over-filled bearings will cause grease or oil to ooze past the seals and collect dirt.

3. Wrap the lubricated bearing assembly in a lint-free shop towel or other appropriate wrapping until the bearing is ready to be installed.

How to Repack Antifriction Bearings with a Bearing Packer

1. Install the bearing packer on the bearing assembly, following the packer manufacturer's directions. (Figure 2)

FIGURE 2



Adapted with permission of The Timken Company.

2. Use the packer to apply grease until all assembly cavities are filled about ⅓ to ½ full.

3. Remove the bearing assembly from the packer and rotate the bearings gently to distribute the grease throughout the bearing.

4. Apply a coat of grease to the inner end and outer edges of the bearing cage.

5. Wrap the packed assembly in specially coated paper until the bearing is ready to be installed.

How to Repack Antifriction Bearings by Hand

1. Make sure your hands are clean and dry.

2. Place a blob of the appropriate bearing grease in the palm of one hand

3. Using the other hand to hold the bearing assembly, press the bearing face into the grease until the grease flows out the top of the bearing.

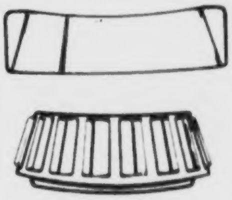
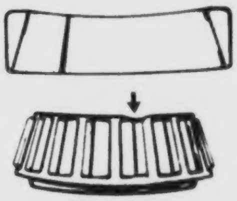
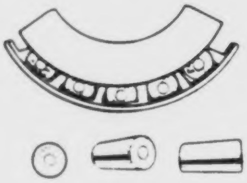
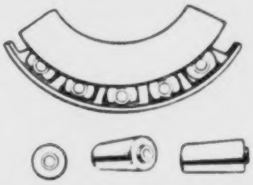
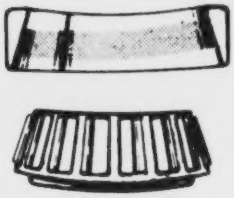
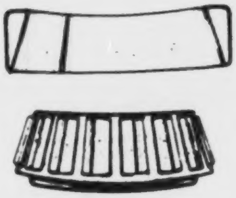
4. Repeat this action, moving the bearing face around until all sections are packed about ⅓ to ½ full.

5. Rotate the bearings gently to distribute the grease throughout the bearing.

6. Wipe excessive amounts of grease off the bearing's outside surfaces.

7. Wrap the packed assembly in specially coated paper until the bearing is ready to be installed.

TAPERED ROLLER BEARING DAMAGE DIAGNOSIS CHART

 **Good bearing**	 **Bent cage** Cage damage due to improper handling or tool usage. Replace bearing.
 **Galling** Metal smears on roller ends due to overheat, lubricant failure, or overload. Replace bearing—check seals and check for proper lubrication.	 **Abrasive step wear** Pattern on roller ends caused by fine abrasives. Clean all parts and housings, check seals and bearings and replace if leaking, rough, or noisy.
 **Misalignment** Outer race misalignment due to foreign object. Clean related parts and replace bearing. Make sure races are properly seated.	 **Indentations** Surface depressions on race and rollers caused by hard particles of foreign material. Clean all parts and housings, check seals and replace bearings if rough or noisy.

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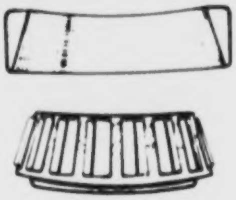
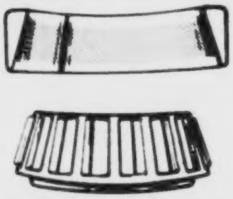
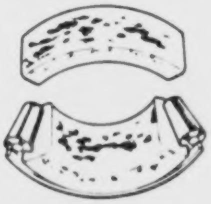
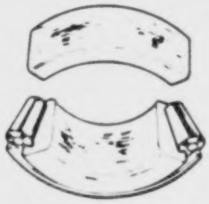
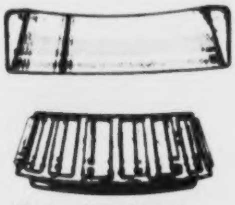
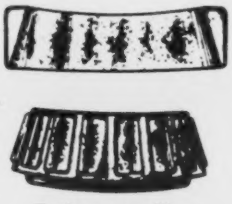
TAPERED ROLLER BEARING DAMAGE DIAGNOSIS CHART (CONTINUED)

 **Cage wear** Wear around outside diameter of cage and roller pockets caused by abrasive material and inefficient lubrication. Check seals and replace bearings.	 **Abrasive roller wear** Pattern on races and rollers caused by fine abrasives. Clean all parts and housings, check seals and bearings and replace if leaking, rough, or noisy.
 **Smears** Smearing of metal due to slippage. Slippage can be caused by poor fits, lubrication, overheating, overloads, or handling damage. Replace bearings, clean related parts, and check for proper fit and lubrication. Replace shaft if damaged.	 **Frettage** Corrosion set up by small relative movement of parts with no lubrication. Replace bearing. Clean related parts. Check seals and check for proper lubrication.
 **Stain discoloration** Discoloration can range from light brown to black caused by incorrect lubricant or moisture. Reuse bearings if stains can be removed by light polishing or if no evidence of overheating is observed. Check seals and related parts for damage.	 **Fatigue spalling** Flaking of surface metal resulting from fatigue. Replace bearing—clean all related parts.

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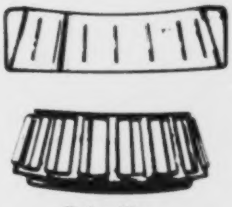
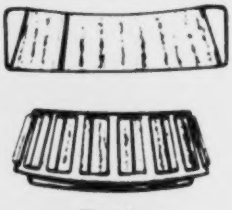
TAPERED ROLLER BEARING DAMAGE DIAGNOSIS CHART (CONTINUED)



Brinelling

Surface indentations in raceway caused by rollers either under impact loading or vibration while the bearing is not rotating.

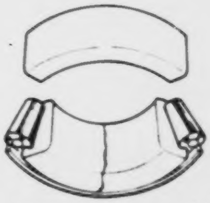
Replace bearing if rough or noisy.



Etching

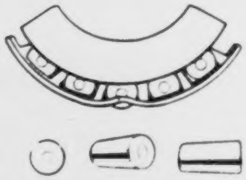
Bearing surfaces appear gray or grayish-black in color with related etching away of material usually at roller spacing.

Replace bearings—check seals and check for proper lubrication.



Cracked inner race

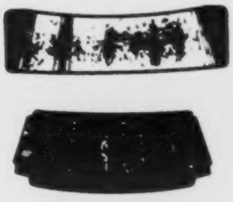
Race cracked due to improper fit, cocking, or poor bearing seats.



Bent cage

Cage damage due to improper handling or tool usage.

Replace bearing.



Heat discoloration

Heat discoloration can range from faint yellow to dark blue resulting from overload or incorrect lubricant.

Excessive heat can cause softening of races or rollers.

To check for loss of temper on races or rollers a simple file test may be made. A file drawn over a tempered part will grab and cut metal, whereas, a file drawn over a hard part will glide readily with no metal cutting.

Replace bearings if overheating damage is indicated. Check seals and other parts.

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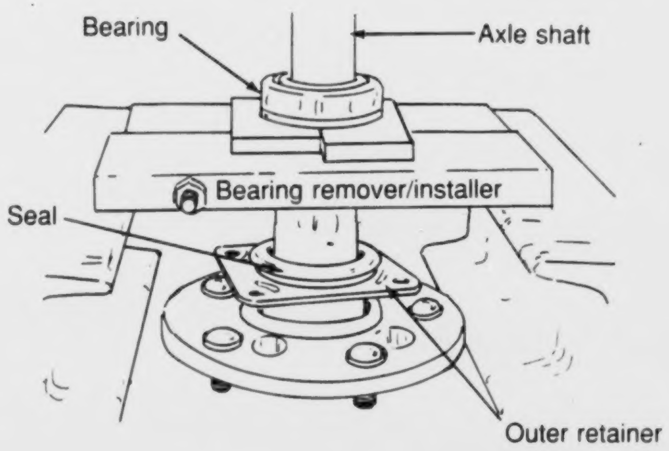
REMOVING AND REPLACING PRESSED-ON BEARINGS

Most antifriction bearings that are used on the axles and in the differential are ***pressed-on***. Pressed-on bearings fit so tightly that special tools and special procedures are required to remove and replace them.

Because pressed-on bearings fit so tightly, they are frequently damaged when they are removed, even if the proper tools are used. Because of this, efforts should be made to clean and inspect the bearings without removing them. However, when bearings must be removed, several methods may be employed.

ARBOR PRESS

FIGURE 1

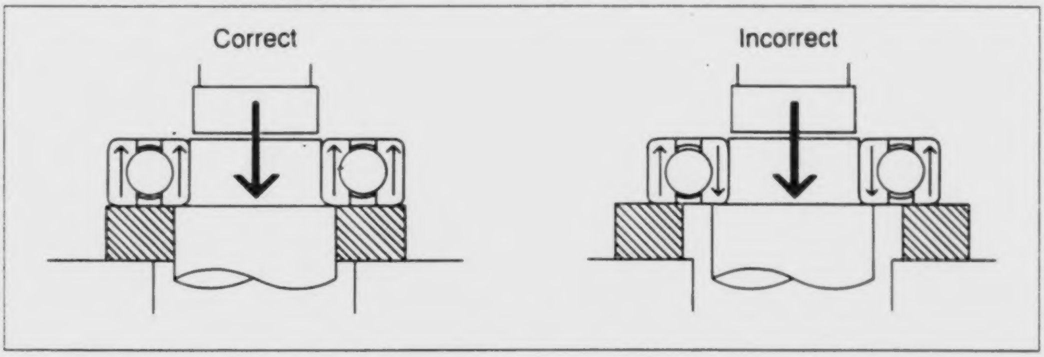


If the part containing the bearing can be placed in an ***arbor press*** (Figure 1), this is usually the easiest and best method for removing and replacing the bearing. An arbor press can exert a great deal of force and using one puts less strain on you and on the bearing. You can also position the press, the shaft, and the bearing accurately and see what you're doing better. The following tips will help you get good, safe results.

- Position the bearing and the shaft so that the downward pressure of the ram presses squarely against the shaft—even a slight angle can cause the parts to be bent or broken.

- The bearing remover or installer should be placed on the arbor press so that support is always given to the bearing's **inner** race. If support is only given to the bearing cage or outer race, the cage will be broken, or the bearings will be pinched between the races. (Figure 2)

FIGURE 2



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- Be sure to place a bearing collar, a generator casing, or other guard around the bearing while it is being pressed on or off. The press exerts great pressure. The collar or casing will protect you in case the bearing explodes while it is being pressed.

WARNING

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NEVER heat a bearing to remove it from a shaft. The flame will ignite the grease or oil that is always present around bearings. Also, the heat will weaken the bearing and cause it to fail.

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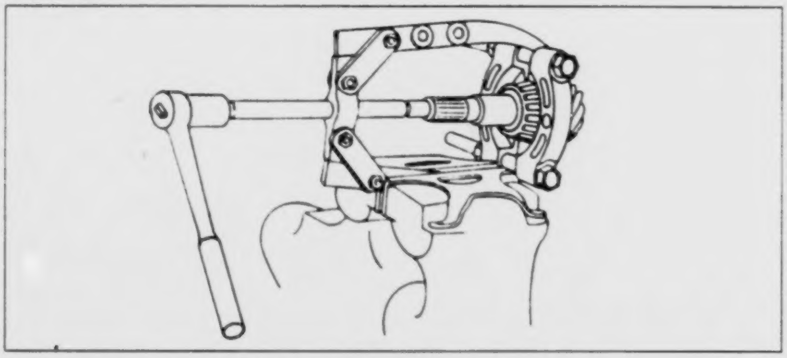
NEVER use a hammer to remove or install a bearing. It's almost impossible to avoid damaging a bearing if a hammer is used, and even a bearing that is bent so slightly that you cannot see the damage can cause a major failure. Hammering can also damage the shaft, the housing, and other parts, sometimes causing metal chips to fly off dangerously.

BEARING PULLERS

If the assembly cannot be put into an arbor press to remove or install the bearing, a ***bearing puller*** can be used. Using a bearing puller requires more effort than an arbor press, but the results can be good if the puller is positioned carefully and steady pressure is used. Some bearing pullers can be used to install bearings as well as remove them. There are several different types:

A ***jaw-type*** puller grips the bearing and pulls against it while the center post pushes against the shaft. (Figure 3)

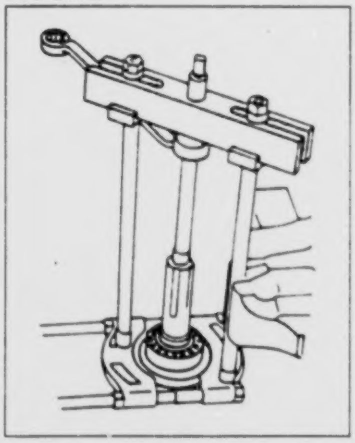
FIGURE 3



Used with permission of CR Seals and Bearings.

A ***push puller*** screws into a special puller plate placed against the bearing. When the center post pushes against the shaft, it pulls the bearing. (Figure 4)

FIGURE 4



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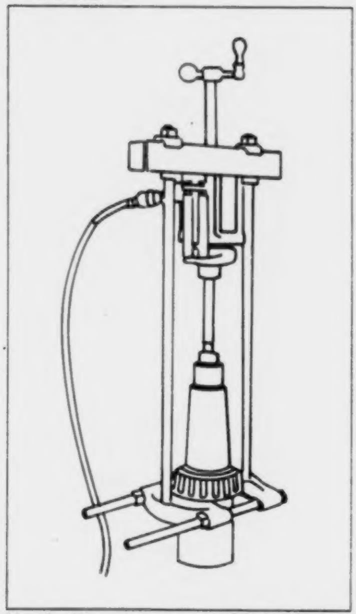
Hydraulic bearing pulleys are more expensive and work in much the same way as other bearing pullers. However because of the hydraulic assistance, they can save time and effort. (Figure 5)

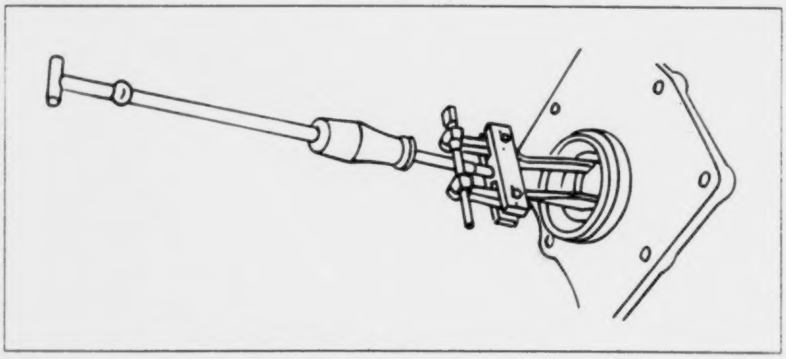
FIGURE 5



Used with permission of CR Seals and Bearings.

A ***slide hammer with a bearing puller attachment*** can be used to remove a bearing or bearing race which has been pressed on the inside of the axle housing. Its jaws grip the bearing while the weighted slide hammer is struck against the stop on the center post. (Figure 6)

FIGURE 6



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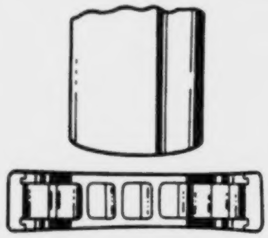
STRAIGHT ROLLER BEARING DAMAGE DIAGNOSIS CHART

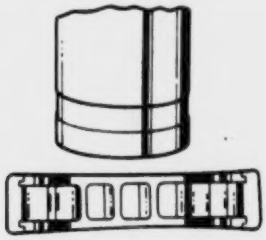


WEAR (MINOR)

Light pattern on races and rollers caused by fine abrasives.

Clean all parts and housings. Check seals and replace bearings if rough or noisy.

Replace shaft if damaged.

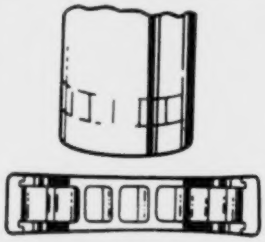


WEAR (MAJOR)

Heavy pattern on races and rollers caused by fine abrasives.

Clean all parts and housings. Check seals and replace bearings if rough or noisy.

Replace shaft if damaged.

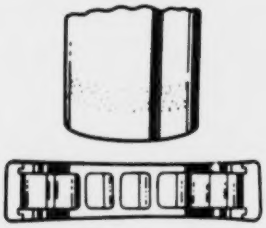


BRINELLING

Surface indentations in raceway caused by roll either under impact loading or vibration while the bearing is not rotating.

Replace bearing if rough or noisy.

Replace shaft if damaged.

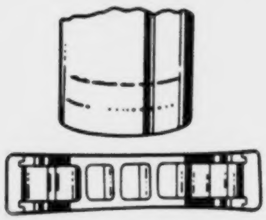


INDENTATIONS

Surface depressions on race and rollers caused by hard particles of foreign material.

Clean all parts and housings. Check seals and replace bearings if rough or noisy.

Replace shaft if damaged.

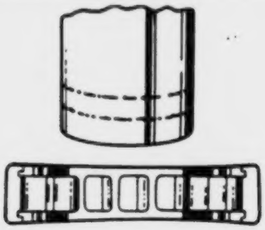


SINGLE EDGE PITTING

Flaking of surface metal resulting from faigue, usually at one edge of race and rollers.

Replace bearings - clean all related parts.

Replace shaft if damaged.

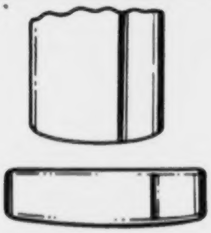


DOUBLE EDGE PITTING

Flaking of surface metal resulting from faigue, usually at both edges of race and rollers.

Replace bearings - clean all related parts.

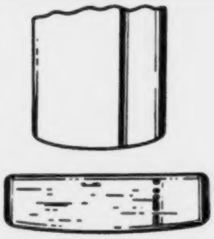
Replace shaft if damaged.



MISALIGNMENT

Replace bearing and make sure races are properly seated.

Replace shaft if bearing operating surface is damaged.

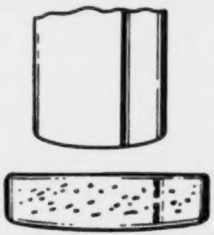


FRETTAGE

Corrosion set up by small relative movement of parts with no lubrication.

Replace bearing. Clean related parts. Check seals and check for proper fit and lubrication.

Replace shaft if damaged.



SMEARS

Smearing of metal due to slippage. Slippage can be caused by poor fits, lack of lubrication, overheating, overloads of handling damage.

Replace bearing. Clean related parts. Check seals and check for proper fit and lubrication.

ASBESTOS

Friction materials such as brake linings and clutch facings often contain asbestos. Millions of asbestos fibers can be released during brake and clutch servicing. Grinding and beveling friction products can cause even higher exposures. Like germs, asbestos fibers are small enough to be invisible and they can remain and accumulate in the lungs. When you see a cloud of dust during brake work, you are seeing clumps containing thousands of fibers.

Asbestos released into the air lingers around a garage long after a brake or clutch job is done and can be breathed by everyone inside the garage, including the customers. While lowering exposure lowers risk, *there is no known level of exposure to asbestos below which health effects do not occur.* The EPA has proposed phasing out the use of asbestos products. In situations where asbestos exposures cannot be eliminated entirely—the auto shop, for instance—exposures must be reduced to the lowest possible level.

Asbestos can be carried on work clothing, contaminating the family car and home This contamination can cause asbestos disease among family members. An ordinary house or shop vacuum cleaner cannot collect these asbestos fibers because the filter is not fine enough to trap them. In fact, an ordinary vacuum cleaner (one that is not equipped with a high-efficiency particulate air, HEPA, filter) is likely to stir up asbestos fibers and scatter them into the air.

Asbestos can also get on a mechanic's hands and be swallowed when the automotive specialist smokes a cigarette or eats. This is a particularly difficult problem for technicians as they often get grease on their hands, and asbestos fibers can stick to the grease.

Until the use of asbestos products is phased out, the best way of limiting health damage is to use proper controls. Effective asbestos containment prevents problems associated with housekeeping and with stirring up settled dust. The best approach is to follow all asbestos safety guidelines designed to contain brake dust and to prevent its release into the shop or garage.

— From Environmental Protection Agency Office of Pesticides and Toxic Substances, Asbestos Action Program, *Guidance for Preventing Asbestos Disease Among Auto Mechanics*, June 1986.

ASBESTOS (CONTINUED)

Safety Guidelines:

- Use the most up-to-date, EPA-approved enclosure-type brake/clutch cleaner equipped with a HEPA-type vacuum cleaner filter.

- Follow enclosure-equipment installation and use procedures to the letter, making sure that equipment is properly in place before any service begins.

- Always follow manufacturer's instructions for changing filter or collection bag.

- **Never** use compressed air to clean the clutch assembly, your clothing, or the work area.

- Do **not** sweep the work area with a broom or garden hose; use a vacuum cleaner equipped with a HEPA filter.

- Dispose of asbestos waste in accordance with EPA's asbestos-disposal guidelines.

- Whenever possible, use pre-ground, installation-ready brake linings.

- Do **not** eat, drink, or smoke in any area where clutch or brake work is done.

- Wash your hands and face before eating and wash all exposed skin and change clothes before going home.

  NOTE: Your employer should see to the laundering of your work clothes. If possible, work clothes should be laundered at special facilities equipped to wash clothing contaminated with asbestos.

- Wear an air-purifying respirator with HEPA cartridges **only** as secondary protection against accidental disturbance of asbestos dust, and **not** as a substitute for the use of enclosure-type equipment.

  NOTE: An air-purifying respirator with HEPA cartridges may be appropriate for *secondary* protection during floor cleaning, filter or collection bag changing, and waste disposal. It should be noted that while NIOSH and EPA do not recommend the use of air-purifying respirators with HEPA cartridges in asbestos environments, various existing regulations currently allow their use.

ASBESTOS (CONTINUED)

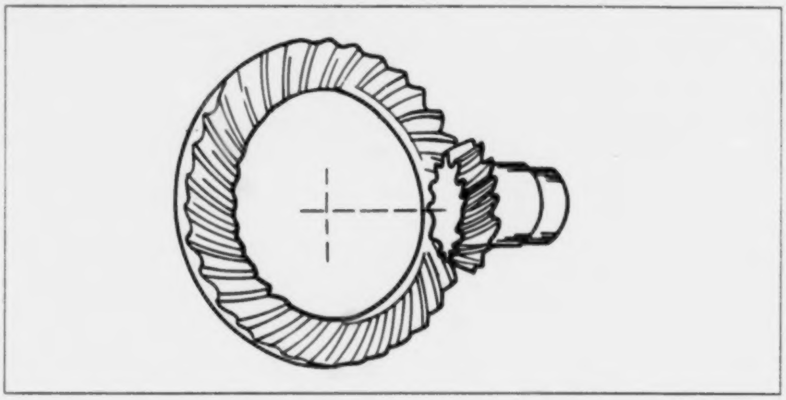
- Even though asbestos friction materials are being phased out, assume for the sake of caution that *all* such materials contain asbestos, and follow appropriate safety guidelines.

- Educate yourself to the dangers of asbestos exposure and take responsibility for your own safety and that of others. Do **not** take a job in a shop that is careless in its asbestos safety procedures and refuse to work or train in an unsafe environment. Your life could depend on it.

HOW TO FIGURE RING TO DRIVE PINION GEAR RATIOS

If either a ring gear or a drive pinion gear is damaged, the technician always replaces **both** of these gears, never just one. When this gear set is replaced, it is important that the replacement parts are identical to the originals. However occasionally, a technician will want to change the gear ratio of the ring and drive pinion gear set.

FIGURE 1



Ring and drive pinion gear ratios for automobiles are usually in a range of 2.56:1 to 4.00:1. Trucks will often use higher ratios such as 4.56:1 or 5.10:1. Lower ratios cut down engine speed, but yield poorer acceleration. A decision to change the ring to drive pinion gear ratio should always take into consideration the weight of the car, the type of service it will have, the engine horsepower, and the gearing in the transmission. ***Changing the ring and drive pinion gear ratio is done only on rare occasions to satisfy special driving needs.***

A gear ratio represents the number of turns made by the drive gear to complete one complete turn of the driven gear.

No. of revolutions of the drive gear	:	No. of revolutions of the driven gear
x.xx	:	1

To calculate the gear ratio of a ring gear to drive pinion gear, divide the number of teeth on the ring gear (driven gear) by the number of teeth on the drive pinion gear (drive gear). Always carry the division out *two* places.

If the ring gear has 41 teeth and the drive pinion gear has 10 teeth, divide 41 by 10:

4.10
Drive gear → 10)41.00 ← Driven gear
(drive pinion gear) 40 (ring gear)
10
10

The ring gear to drive pinion gear ratio of this gear set is 4.10:1.

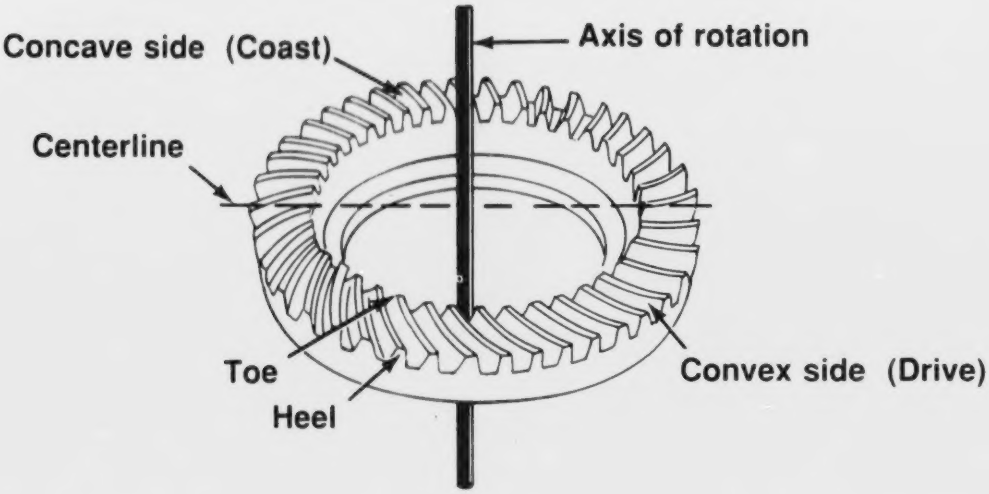
If the ring gear has 44 teeth and the drive pinion has 16 teeth, divide 44 by 16:

2.75
16)44.00
32
120
112
80
80

The gear ratio of this gear set is 2.75:1

Activity Sheet 2 contains practice problems for calculating ring to drive pinion gear ratios.

Parts of a Gear


Concave side (Coast)
Axis of rotation
Centerline
Toe
Heel
Convex side (Drive)

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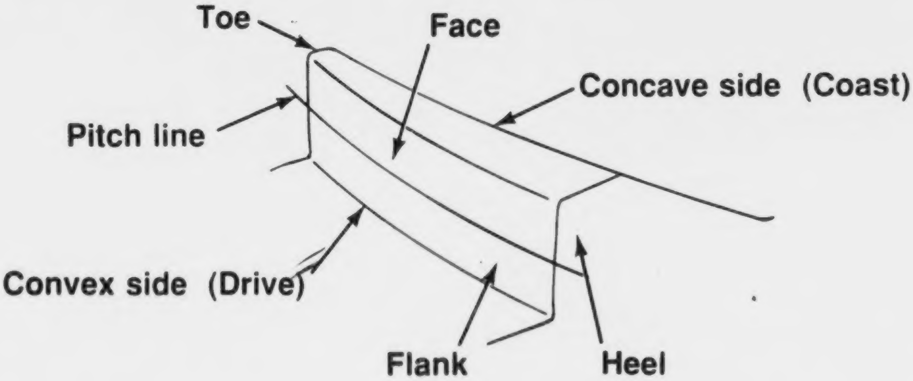
Parts of a Gear Tooth


Toe
Face
Concave side (Coast)
Pitch line
Convex side (Drive)
Flank
Heel

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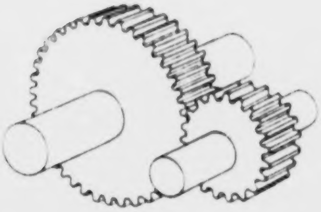
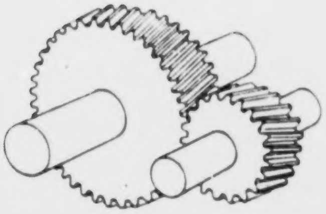
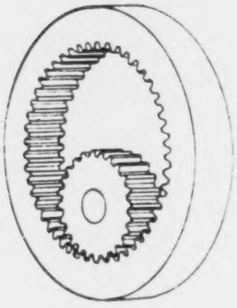
Spur Gear



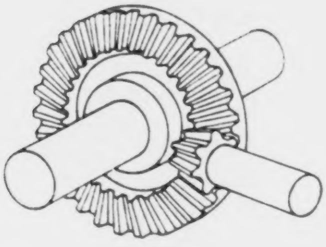
Helical Gear



Internal Gear



Straight Bevel Gear



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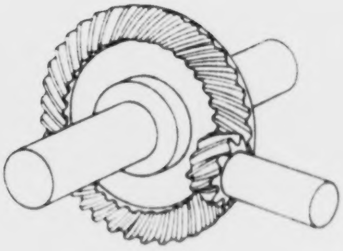
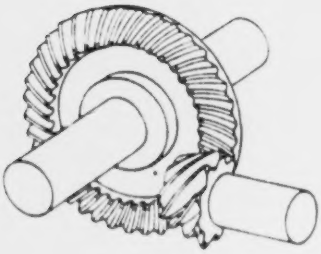
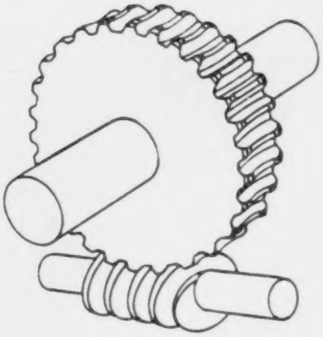
Spiral Bevel Gear



Hypoid Gear



Worm Gear



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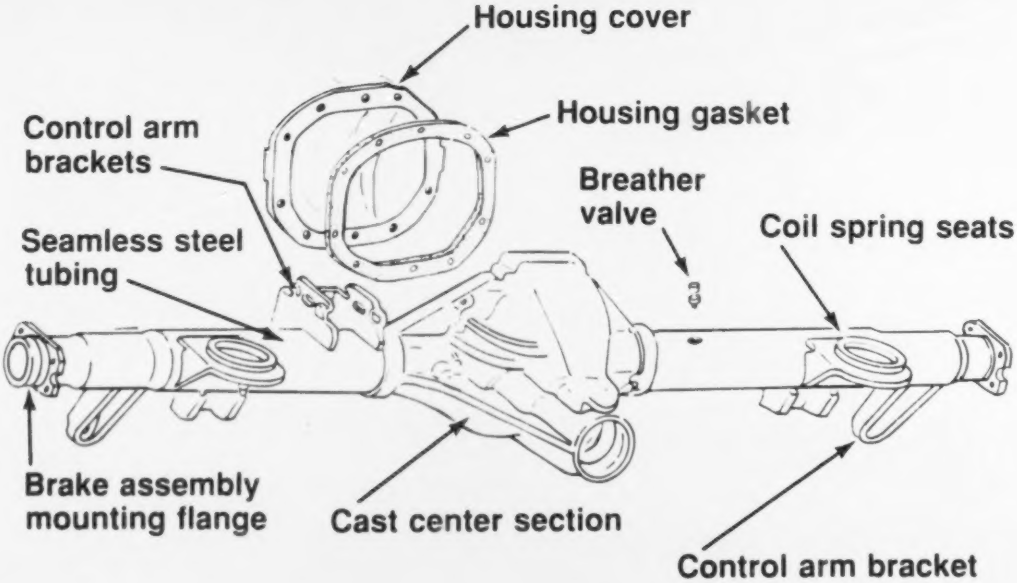
Integral Carrier Axle Housing


Housing cover
Housing gasket
Control arm brackets
Breather valve
Coil spring seats
Seamless steel tubing
Brake assembly mounting flange
Cast center section
Control arm bracket

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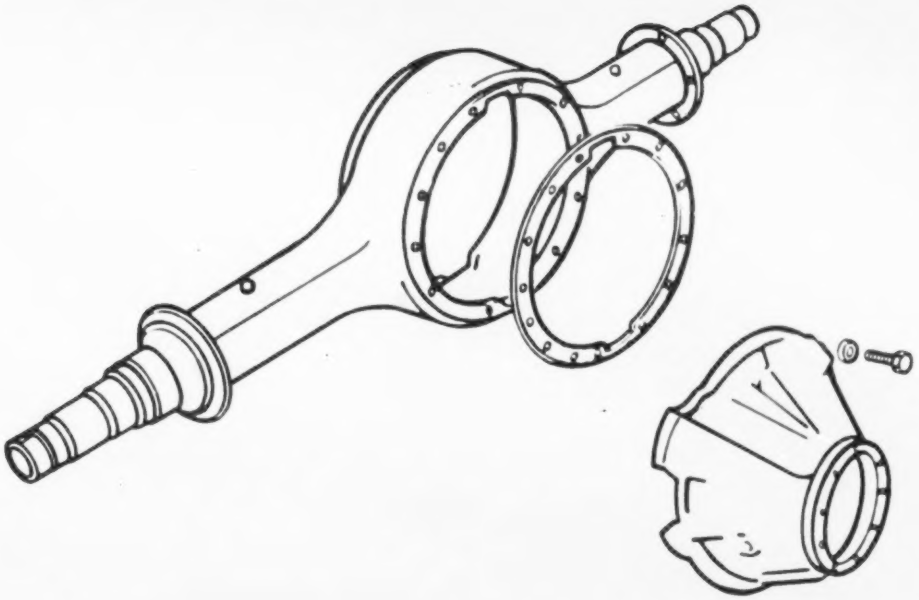
Removable Carrier Axle Housing



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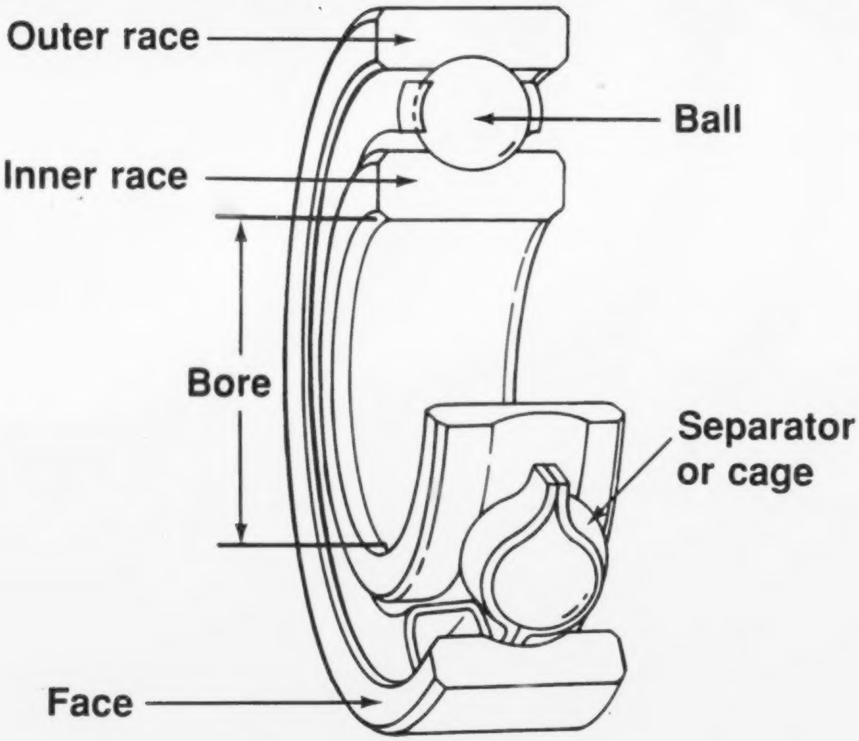
Ball Bearing


Outer race
Ball
Inner race
Bore
Separator or cage
Face

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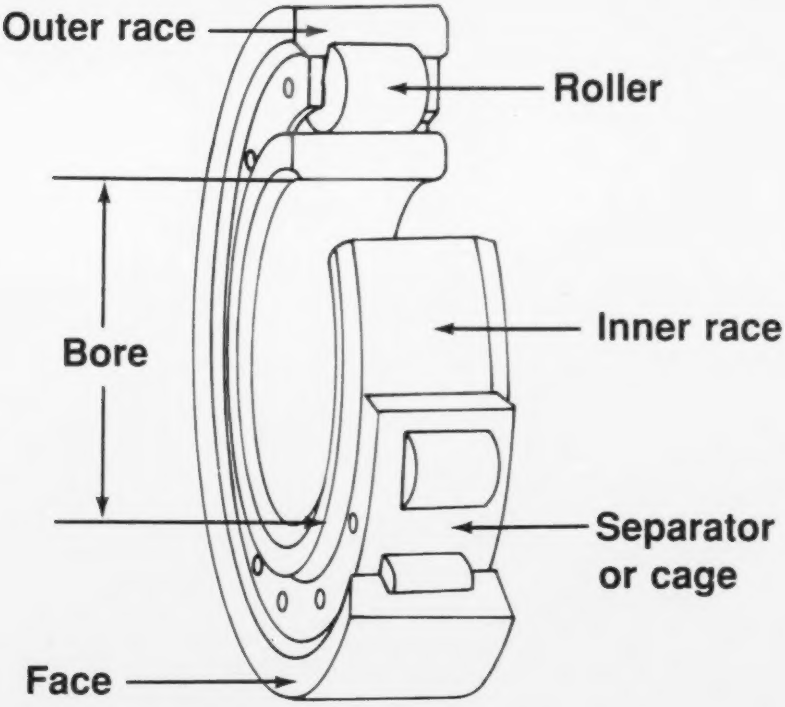
Straight Roller Bearing


Outer race
Roller
Bore
Inner race
Separator
or cage
Face

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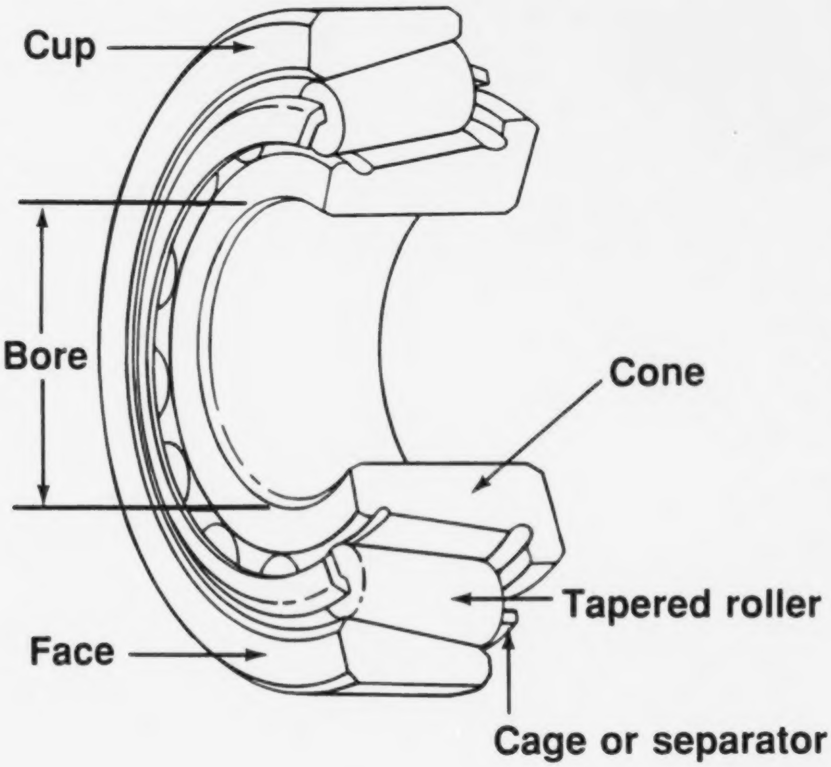
Tapered Roller Bearing


Cup
Bore
Cone
Tapered roller
Face
Cage or separator

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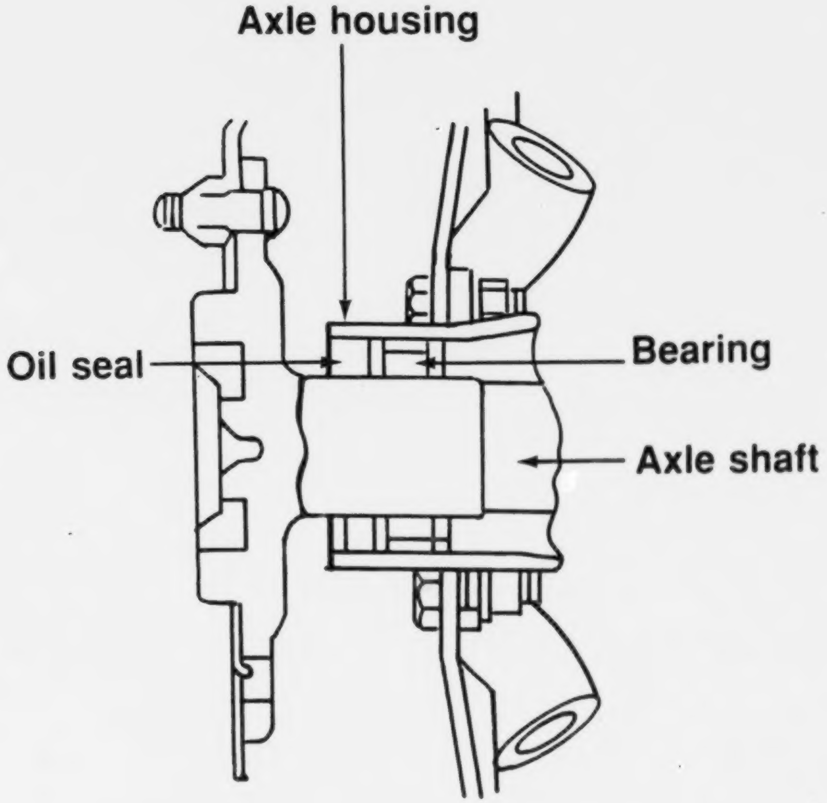
Semi-Floating Axle


Axle housing
Oil seal
Bearing
Axle shaft

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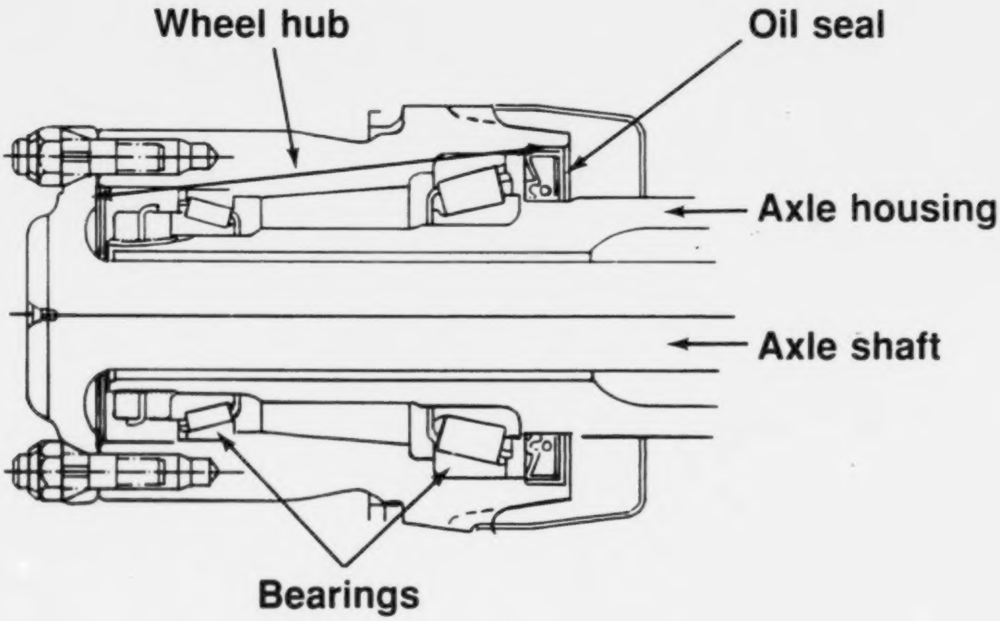
Full-Floating Axle


Wheel hub
Oil seal
Axle housing
Axle shaft
Bearings

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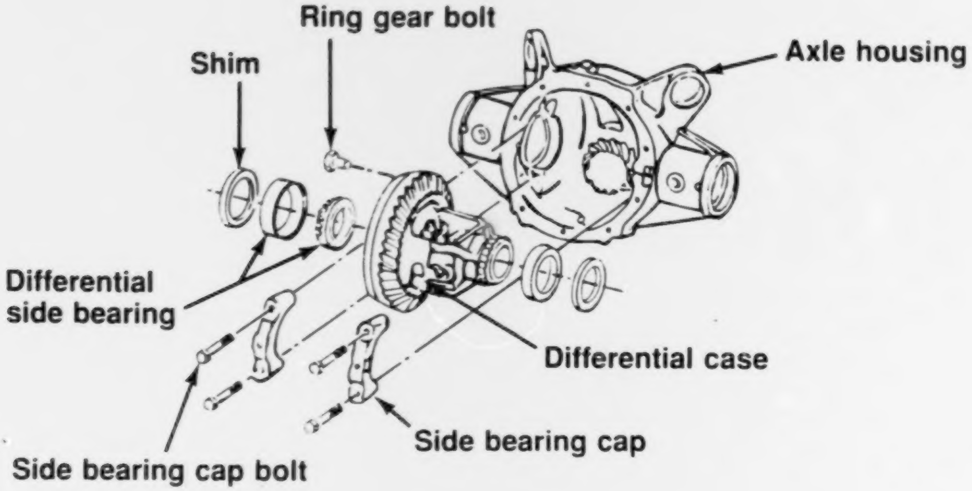
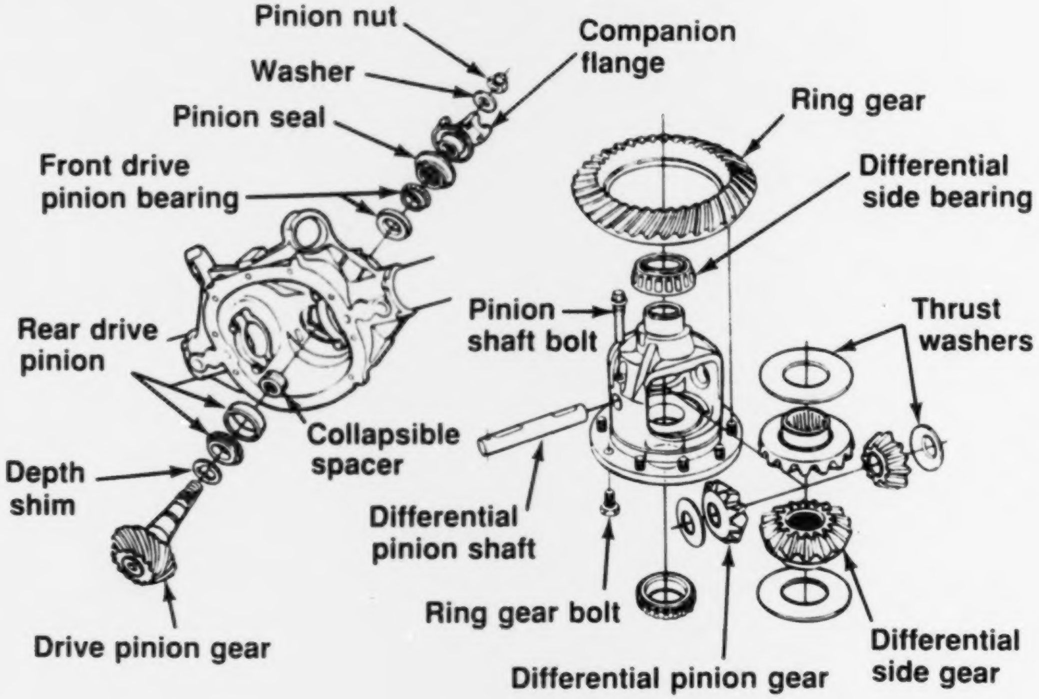
Conventional Differential


Ring gear bolt
Shim
Axle housing
Differential side bearing
Differential case
Side bearing cap
Side bearing cap bolt


Pinion nut
Companion flange
Washer
Pinion seal
Ring gear
Front drive pinion bearing
Differential side bearing
Pinion shaft bolt
Thrust washers
Rear drive pinion
Collapsible spacer
Depth shim
Differential pinion shaft
Ring gear bolt
Drive pinion gear
Differential pinion gear
Differential side gear

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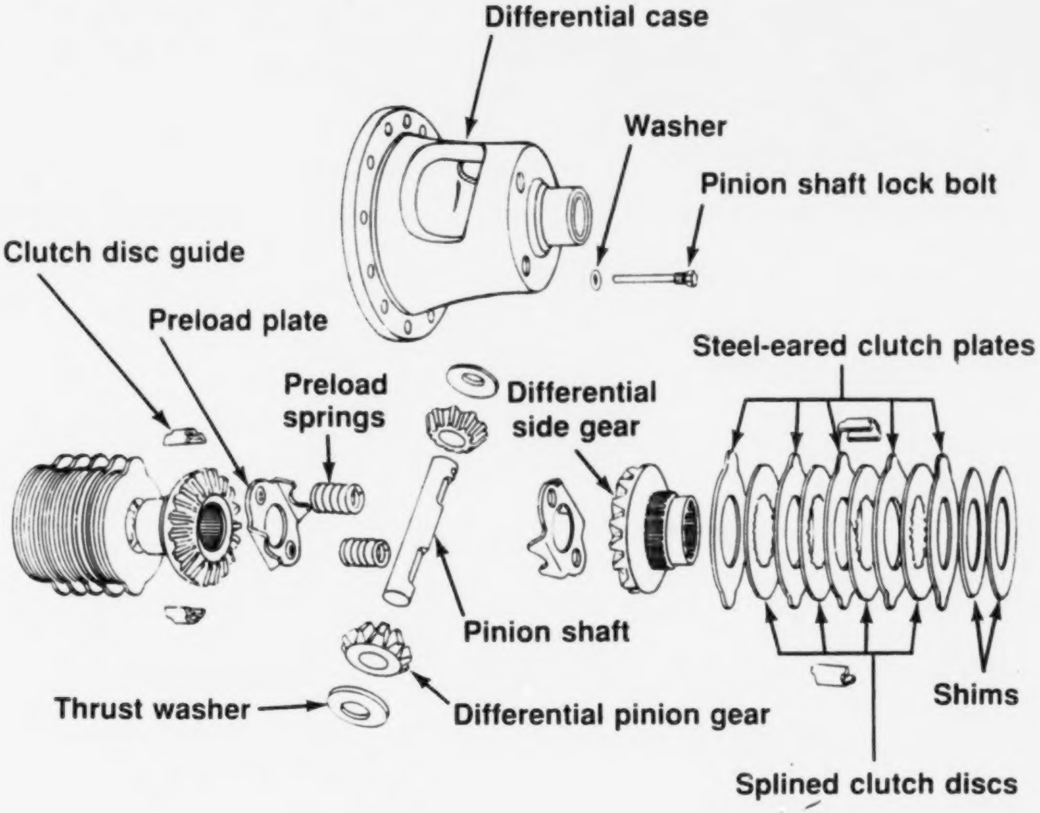
Clutch Plate Type Limited-Slip Differential


Differential case
Washer
Pinion shaft lock bolt
Clutch disc guide
Preload plate
Preload springs
Differential side gear
Steel-eared clutch plates
Pinion shaft
Thrust washer
Differential pinion gear
Shims
Splined clutch discs

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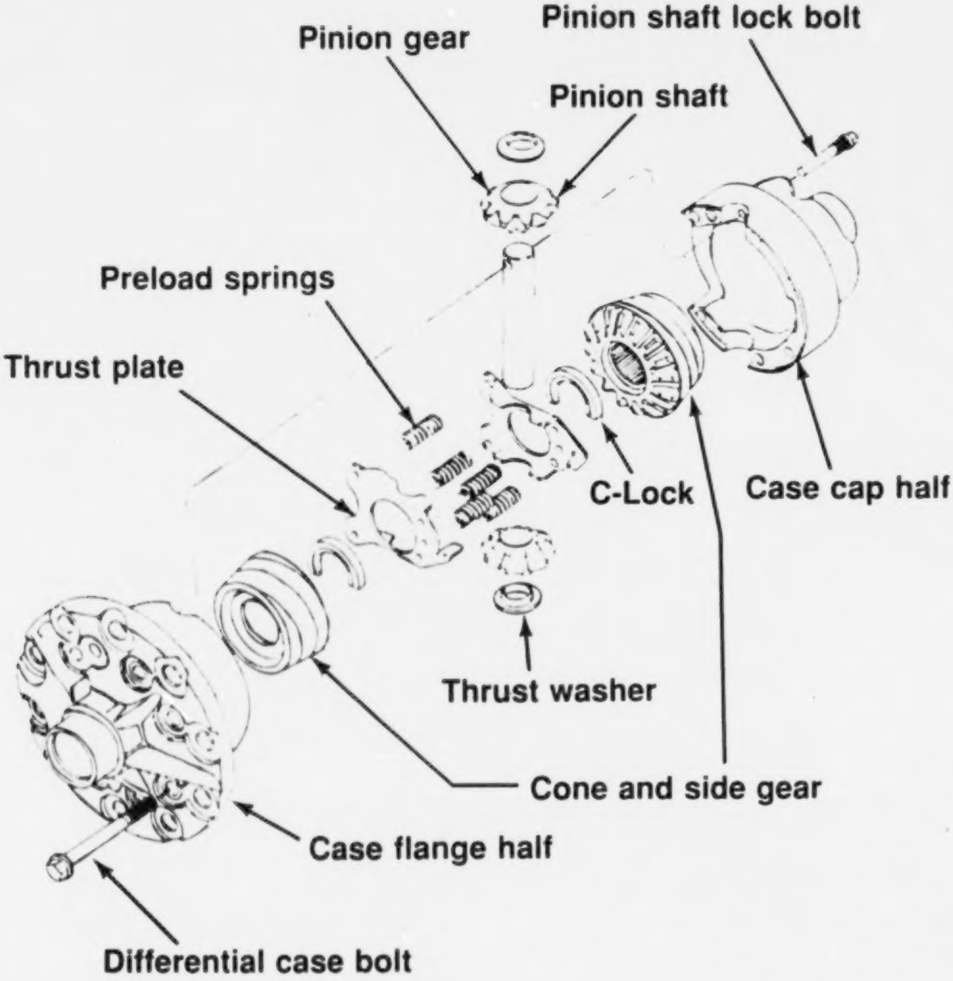
Cone Type Limited-Slip Differential


Pinion gear
Pinion shaft lock bolt
Pinion shaft
Preload springs
Thrust plate
C-Lock
Case cap half
Thrust washer
Cone and side gear
Case flange half
Differential case bolt

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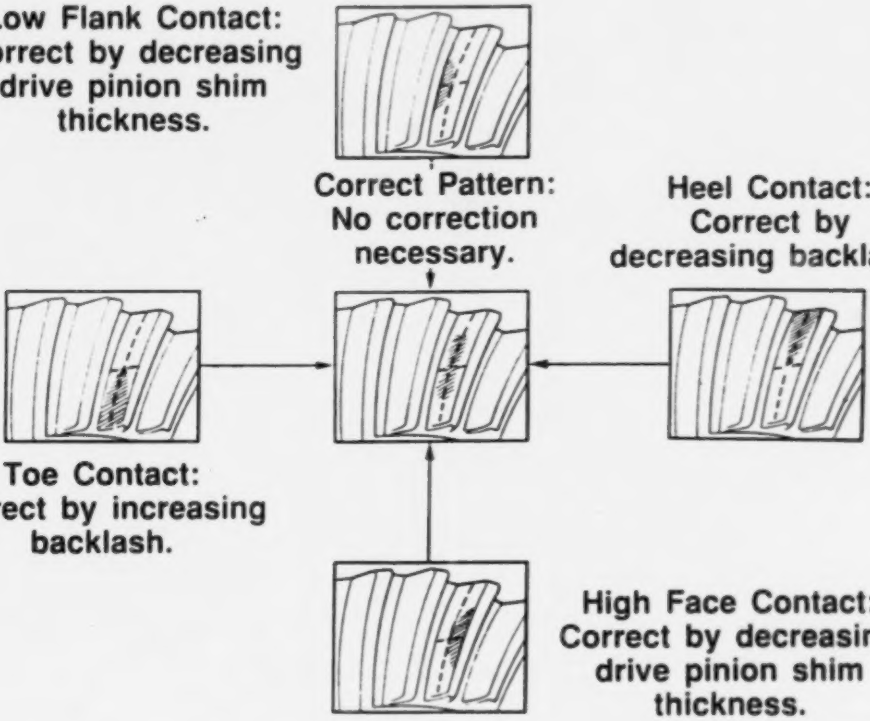
Ring Gear Tooth Contact Pattern Diagnosis



Low Flank Contact:
Correct by decreasing drive pinion shim thickness.

Correct Pattern:
No correction necessary.

Heel Contact:
Correct by decreasing backlash.

Toe Contact:
Correct by increasing backlash.

High Face Contact:
Correct by decreasing drive pinion shim thickness.

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USING RING GEAR TOOTH CONTACT PATTERNS TO DETERMINE NEEDED DIFFERENTIAL ADJUSTMENTS

NAME ______________________________ SCORE ________

INTRODUCTION

Examining the patterns on the ring gear teeth made by the ring gear contact pattern test can help the Manual Drivetrain and Axles Specialist determine what adjustments must be made to the differential to bring it into proper operation. However, the proper diagnosis can only be made if the Drivetrain and Axles Specialist can correctly interpret these tooth contact patterns. This exercise will give you experience in this type of diagnosis.

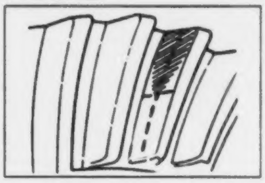
DIRECTIONS

Refer to the Information Sheet, Objective 11, for information on using ring gear tooth contact patterns to identify needed differential adjustments.

Circle the letter(s) before the adjustment(s) needed to correct the ring gear tooth contact pattern shown. **Some patterns will show that more than one adjustment is needed.**

1. A. Increase drive pinion shim thickness
   B. Decrease drive pinion shim thickness
   C. Increase backlash
   D. Decrease backlash
   E. No adjustment necessary

FIGURE 1



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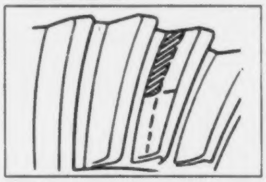
2. A. Increase drive pinion shim thickness
   B. Decrease drive pinion shim thickness
   C. Increase backlash
   D. Decrease backlash
   E. No adjustment necessary

FIGURE 2



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3. A. Increase drive pinion shim thickness

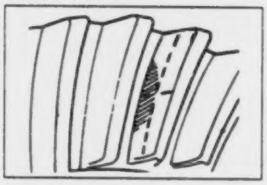
B. Decrease drive pinion shim thickness

C. Increase backlash

D. Decrease backlash

E. No adjustment necessary

FIGURE 3



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4. A. Increase drive pinion shim thickness

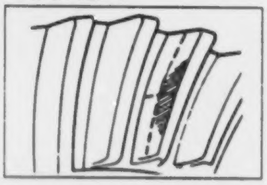
B. Decrease drive pinion shim thickness

C. Increase backlash

D. Decrease backlash

E. No adjustment necessary

FIGURE 4



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5. A. Increase drive pinion shim thickness

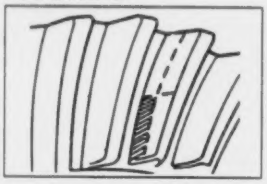
B. Decrease drive pinion shim thickness

C. Increase backlash

D. Decrease backlash

E. No adjustment necessary

FIGURE 5



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6. A. Increase drive pinion shim thickness

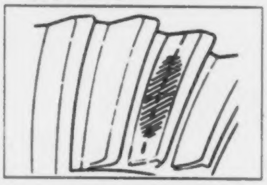
B. Decrease drive pinion shim thickness

C. Increase backlash

D. Decrease backlash

E. No adjustment necessary

FIGURE 6



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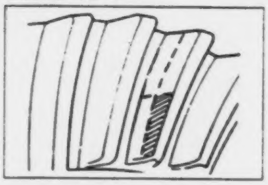
7. A. Increase drive pinion shim thickness
   B. Decrease drive pinion shim thickness
   C. Increase backlash
   D. Decrease backlash
   E. No adjustment necessary

FIGURE 7



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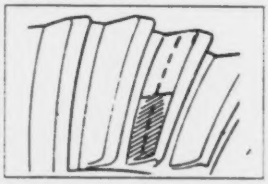
8. A. Increase drive pinion shim thickness
   B. Decrease drive pinion shim thickness
   C. Increase backlash
   D. Decrease backlash
   E. No adjustment necessary

FIGURE 8



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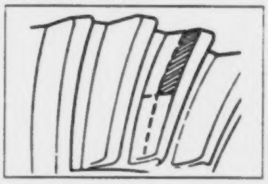
9. A. Increase drive pinion shim thickness
   B. Decrease drive pinion shim thickness
   C. Increase backlash
   D. Decrease backlash
   E. No adjustment necessary

FIGURE 9



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FIGURING RING TO DRIVE PINION GEAR RATIOS

NAME ______________________________ SCORE ______

INTRODUCTION

Remember: A gear ratio represents the number of turns made by the drive gear to complete one complete turn of the driven gear.

No. of revolutions of the drive gear : No. of revolutions of the driven gear

x.xx : 1

DIRECTIONS

Use Supplement 10, ***How to Figure Ring to Drive Pinion Gear Ratios***, to help you with the following gear ratio problems. Put the answer to the problem in the blank in front of the number.

__________ 1. What is the ring to pinion gear ratio of a ring and pinion set in which the ring gear has 39 teeth and the drive pinion gear has 13 teeth?

$13\overline{)39}$

__________ 2. What is the ring to pinion gear ratio of a ring and pinion set in which the ring gear has 35 teeth and the drive pinion gear has 10 teeth?

$10\overline{)35}$

____________3. The ring gear has 45 teeth and the drive pinion gear has 18 teeth. What is the gear ratio of the set?

$$18\overline{)45}$$

____________4. What is the gear ratio of a ring and pinion set in which the ring gear has 42 teeth and the drive pinion gear has 13 teeth?

____________5. If the ring gear has 45 teeth and the drive pinion gear has 11 teeth, what is the gear ratio?

____________6. What is the gear ratio of the set if the ring gear has 40 teeth and the drive pinion gear has 13 teeth?

____________7. What is the ring to pinion gear ratio of a ring and pinion set in which the ring gear has 46 teeth and the drive pinion gear has 17 teeth?

____________8. What is the gear ratio of set in which the ring gear has 32 teeth and the drive pinion gear has 7 teeth?

____________9. If the ring gear has 38 teeth and the drive pinion gear has 11 teeth, what is the gear ratio of the set?

____________10. What is the gear ratio of the set when the ring gear has 37 teeth and the drive pinion gear has 9 teeth?

ACTIVITY ANSWERS

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

ACTIVITY SHEET 1

1. D
2. B, D
3. B
4. A
5. B, C
6. E
7. A, C
8. C
9. A, D

ACTIVITY SHEET 2

1. 3.00:1
2. 3.50:1
3. 2.50:1
4. 3.23:1
5. 4.09:1
6. 3.08:1
7. 2.71:1
8. 4.57:1
9. 3.45:1
10. 4.11:1

ASSIGNMENT SHEET 1

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES II

NAME ______________________ SCORE ______

OBJECTIVE 12

Diagnose differential and rear drive axle leak, noise, and performance problems.

INTRODUCTION

To diagnose differential and rear axle problems, the Manual Drivetrain and Axles Specialist will need to make both a road test and a visual examination of the vehicle. The most common symptom of problems with the differential or rear drive axles is unusual noise. Even though a noise or vibration may seem to come from the rear end, other possibilities should be considered. Bad tires or alignment, exhaust components hitting against the frame, or damaged engine mounts are a few possibilities.

Any lubrication leak in the rear axle housing is a danger to the entire rear axle and differential. Because they operate at high speed, these components must be properly lubricated at all times to avoid severe damage. Checking for leaks in the rear axle housing is an important part of rear axle and differential diagnosis. Any other repair, however necessary, can be quickly undone if the technician overlooks a leak in the housing. For this reason, the technician will often clean the outside of the housing before he makes the road test so that any leaks can be easily seen. If the rear axle lubricant level is low when a problem is reported, special attention should be given to checking for lubricant leaks.

Making a careful road test can help the specialist make an educated guess about the probable cause of the noise, but it is the visual examination of the components as well as tests on those components which will yield the final diagnosis.

DIRECTIONS

Use Supplement 1, ***Making a Rear Axle/Differential Noise Diagnosis***, Supplement 2, ***Rear Axle Housing Lubrication Leak Diagnosis Chart***, Supplement 3, ***Rear Axle/Differential Noise Diagnosis Chart***, and Supplement 4, ***Rear Axle/ Differential Performance Diagnosis Chart***, to help answer the following questions. Select the answer for each that is **most** correct. Write the correct letter in the blank.

______1. Which of the following should be done **first** when diagnosing rear axle/differential noise?

A. Inspect the axle housing
B. Verify the noise with a short road test
C. Talk to the vehicle's owner about the nature of the problem
D. Drive the car in different modes to try to identify the type of noise

______2. During a diagnostic road test, there is a knocking noise from the vehicle's rear end which is present only when you drive on rough roads. What is the **most** probable cause?

A. Low rear axle lubricant level
B. Worn axle bearing
C. Ring and pinion gear damage
D. Axle shaft end play

______3. The technician has not adjusted the ring and pinion backlash correctly. Which of the following might result?

A. Broken ring and pinion gear teeth
B. Clunking during acceleration or deceleration
C. Chuckling when slowing down or stopping
D. All of the above

______4. A vehicle you are servicing has broken ring and pinion gear teeth. Which of the following conditions is most likely to have caused the breakage?

A. Companion flange runout
B. Worn axle bearings
C. Incorrect ring and pinion backlash
D. Worn thrust washers

______5. The most common symptom of drive axle or differential problems is:

A. Noise
B. Vibration
C. Leakage
D. Inoperative drive axle

______6. Once you have identified the nature and location of a rear axle/differential noise, which of the following tests will help you **most** in locating the cause of the noise?

A. Visual check for leaks
B. Road test in different driving modes
C. Ring gear tooth contact pattern test
D. Side bearing preload test

______7. Why would a technician steam clean the axle housing as part of his diagnostic procedures?

A. To be able to see the rear axle/differential components better
B. Because cleaning rear axle/differential components might solve some minor problems in this area
C. Because the area must be clean in order to get accurate test results
D. So rear axle/differential leaks can be seen easier

______8. If you apply the brakes lightly during a test drive, what rear axle/driveline noise will be reduced?

A. Wheel bearing noise
B. Axle bearing noise
C. Differential pinion gear noise
D. Drive pinion bearing noise

______9. On the road test, there is a groaning noise which continues even when the car is put in reverse. What is the probable cause?

A. Drive pinion bearing
B. Ring and pinion gear damage
C. Worn thrust washers
D. Wrong rear axle lubricant

_____10. Which of the following is **not** one of the approved corrective actions designed to stop a lubricant leak located at a nut?

A. Tighten the nut as tight as possible
B. Apply a sealer to the bolt threads
C. Clean the threads with an approved cleaning solvent
D. Torque the nut to specification

_____11. If the vehicle's differential is not working freely on turns, what might be the probable cause?

A. Bad axle bearings
B. Problem with the ring and pinion gears
C. Worn limited-slip clutches
D. Damaged differential side gear

_____12. Which of the following is something you might look for when making a visual check of a vehicle prior to making a road test for noise diagnosis?

A. Incorrect ring gear tooth contact patterns
B. Damaged or worn rear axle/differential bearings
C. Exhaust system components that might be rubbing against the frame
D. Damaged oil seals

_____13. If the vehicle's rear axle/differential makes a whining noise which changes as the vehicle's speed changes, what is the most probable cause?

A. Low lubricant level
B. Bad bearing
C. Bad gear
D. Ring and pinion gear backlash problem

_____14. A customer complains of rear axle/differential noise. Which of the following possible causes does the technician try to eliminate **first**?

A. The tires are bad or out of alignment
B. Steering or exhaust system components are rubbing against the vehicle frame
C. The noise level matches that of other identical vehicles which operate normally
D. The noise may be coming from some other part of the vehicle

ASSIGNMENT ANSWERS

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

ASSIGNMENT SHEET 1

1. C
2. D
3. D
4. C
5. A
6. C
7. D
8. A
9. D
10. A
11. B
12. C
13. B
14. C

JOB SHEET 1

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13A

Inspect the rear axle housing and flush and refill the rear axle lubricant.

INTRODUCTION

The rear axle housing contains several pints of lubricant and is designed with built-in channels which work with the movement of the differential to encourage circulation of the lubricant to the components operating in the housing.

Rear axle lubricant does not deteriorate under normal driving conditions, but it does become contaminated. The lubricant level should be checked, and needed lubricant added whenever the vehicle is hoisted for other routine lubrication. Rear axle lubricant should be changed when it becomes contaminated or as recommended by the manufacturer—this will be at least every 25,000 miles, although in dusty areas it may need to be changed as frequently as engine oil.

The vehicle's service manual lists the type and amount of lubricant and additives that should be used, as well as the schedule recommended for lubrication changes. There are many different types of differentials in use, and each has unique operating requirements that can only be met by using a specified lubricant or lubricant plus additives. All rear axle lubricants are not the same—using the wrong type or amount can seriously damage the vehicle. This is especially true for vehicles with limited-slip differentials which use a totally different type of lubricant.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Hoist or jack and stands
- Approved cleaning solvent
- Stiff brush
- Shop towels
- Equipment to steam clean axle housing (optional)
- Shop light
- Drain pan
- Combination wrenches
- Torque wrench
- Rear axle lubricant and additives specified for the vehicle being used
- Lube gun, syringe, or suction gun

If there is no drain plug, you will also need:

- Suction gun with hose extension

If axle housing cover must be removed, you will also need:

- Wide-blade screwdriver
- Putty knife
- New axle housing gasket or sealant

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect the rear axle housing

1. Raise the vehicle and support it safely.
2. Use an approved cleaning solvent and a stiff brush to clean the outside of the axle housing; wipe with clean shop towels.
3. If needed, steam clean the outside of the housing to remove grease and grit.
4. Use a shop light to examine the outside of the carrier or housing for cracks, broken welds, casting porosity, or other damage.

   NOTE: If casting porosity exists, peen the housing with body lead and finish off with an epoxy sealer. For large pockets of porosity, drill a shallow hole and install a set screw, then finish off with epoxy sealer.

5. If the housing is cracked or has broken welds, replace the housing.
6. If the vehicle has a vent hose, make sure it is unclogged and in good condition; make sure the vent works properly.
7. Lower the vehicle and drive for a short distance.
8. Raise the vehicle and examine the housing welds and sealing surfaces for leaking lubricant.

PROCEDURE

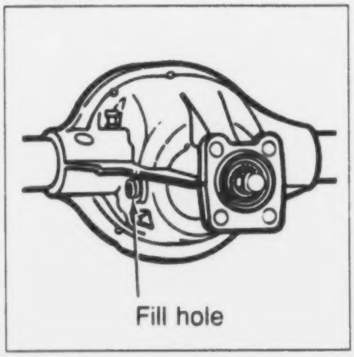
Flush rear axle lubricant

1. Use the vehicle's service manual to locate the appropriate rear axle lubrication specifications for the vehicle.

2. Locate the fill hole and drain plug on the axle housing. (Figure 1)

   NOTE: In different positions on different vehicles, the fill hole is usually located at the back or side of the differential and the drain plug is usually located at the bottom.

FIGURE 1



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3. Wipe off the fill plug with a shop towel.

   NOTE: Fill plugs are often made of rubber or plastic.

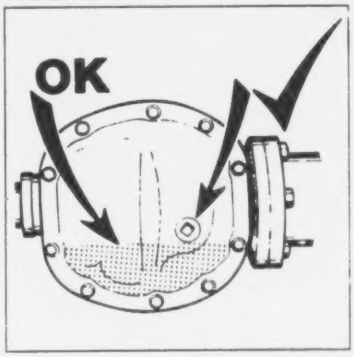
4. Use the proper wrench to remove the plug.

5. Examine the plug for deterioration and replace it if necessary.

6. Put your finger or a bent rod into the fill hole and determine whether or not the lubricant level is within service manual specifications. (Figure 2)

   NOTE: If no fill height is specified, the lubricant should come to within ½ inch below the fill hole.

FIGURE 2



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7. Examine the lubricant and rub it between your fingers.

   NOTE: Poor rear axle lubricant can be dark, gritty, and foamy. It may smell like varnish and have moisture in it. Change the lubricant at least as often as the manufacturer recommends.

PROCEDURE

If there is a drain plug

1. Position a drain pan below drain plug.

   NOTE: Sometimes a housing bolt is used as a drain plug. If this is the case, it can often be located by the copper or aluminum washer used with it.

2. Wipe off the drain plug with a shop towel.
3. Use the proper wrench to remove the drain plug.
4. Allow the lubricant to drain completely.
5. Replace the drain plug firmly; torque to specifications if appropriate.

PROCEDURE

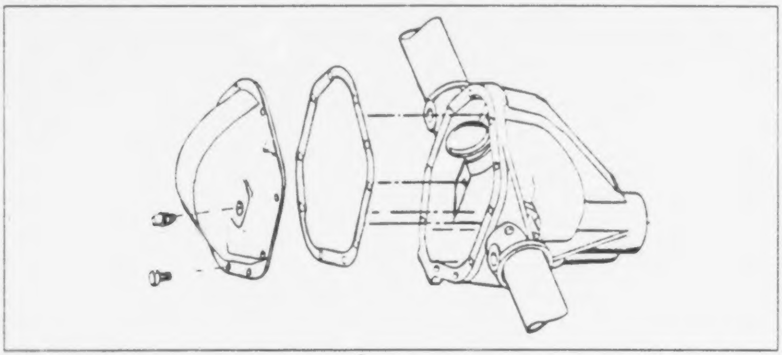
If there is no drain plug—Integral Carrier

1. Position the drain pan below the housing cover.
2. Wipe off and remove the fill plug.
3. Use the proper wrench to remove the cover's bolts, starting with the bottom bolts. (Figure 3)

   CAUTION

   The lubricant may begin to flow out when the bolts are removed.

FIGURE 3



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4. Working from the bottom, pry the rear cover away from the housing with a screwdriver, being careful not to damage the gasket sealing surface.

5. Allow the lubricant to drain completely.

6. Use a shop towel to wipe out the bottom of the differential housing, removing any metal particles.

7. Use a putty knife to remove the old gasket or sealant from the rear cover.

8. Clean the cover's sealing surface with an approved cleaning solvent.

9. Position the new gasket or sealant according to manufacturer's recommendations.

10. Replace the rear cover and tighten the cover bolts to torque specifications using a star pattern.

PROCEDURE

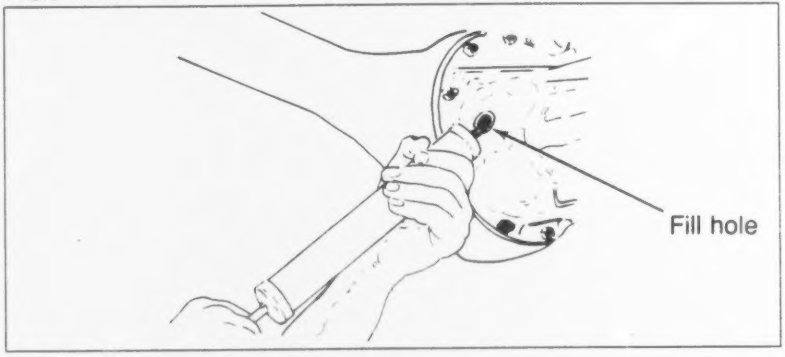
If there is no drain plug—Removable Carrier

1. Position the drain pan below the housing's fill hole.

2. Wipe off and remove the fill plug.

3. Insert the suction gun's hose into the bottom of the differential case and suck out the lubricant. (Figure 4)

FIGURE 4



4. Repeat until the lubricant is removed from the housing.

PROCEDURE

Refill rear axle lubricant

1. Add the lubricant and additives specified by the vehicle manufacturer to the recommended height, using a lube gun, syringe, or suction gun.

2. Replace and tighten the fill plug; torque to specifications if appropriate.

3. Remove the drain pan.

4. Lower the vehicle on the hoist.

5. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 2

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

OBJECTIVE 13B

Remove rear axle shafts.

INTRODUCTION

When the differential or drive axles must be disassembled for service or repair, it is first necessary to remove the rear axle shafts from the vehicle.

Rear axle shafts are usually held on the vehicle in one of two ways. On vehicles which have an integral carrier axle housing, C-locks are clipped around the inner end of the axle shaft, locking it in place inside the differential case. This is the most common method of securing the axle shafts. Removal of axle shafts using C-locks requires that the carrier housing be drained of lubricant and the housing cover removed.

Vehicles with removable carriers most frequently have retainer plates on the outside ends of the axle housing which hold the axle shafts in place. It is not necessary to open the axle housing or drain the lubricant to remove axles secured by retainer plates. The rear wheels and brake drums must be removed on both types of axle shafts.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection

For axle shafts secured by C-locks, you will also need:

- Shop light
- Shop towels
- Combination wrenches
- Hammer
- Brass drift
- Pliers

For axle shafts secured by retainer plates you will also need:

- Sockets, extensions, and ratchets
- Slide hammer with axle adapter
- Mechanic's wire

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported. The wheels and brake drums should be removed from the axle ends. **Watch for asbestos when brake drums are removed.** If asbestoes is present, refer to Supplement 9, "Asbestos," for appropriate safety procedures. If the vehicle has an integral carrier housing, the rear axle lubricant should be drained, and the rear housing cover removed. (Job Sheet 1)

PROCEDURE

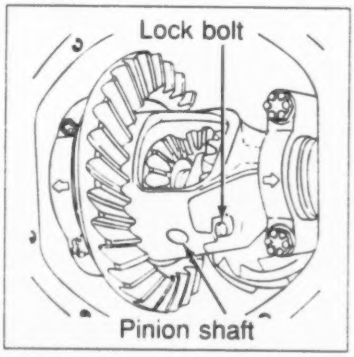
To remove an axle secured by a C-lock

1. Rotate the differential case to expose the differential pinion shaft lock bolt and the C-lock. (Figure 1)
2. Wipe off the pinion shaft lock bolt and the C-lock with a shop towel.
3. Use an appropriate wrench to carefully remove the differential pinion shaft lock bolt

CAUTION

Differential pinion shaft lock bolts break easily.

FIGURE 1



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4. If necessary, use a hammer and brass drift to remove the differential pinion shaft.

CAUTION

Avoid rotating the axle shaft or the differential case while the differential pinion shaft is out—the differential case components will fall apart.

5. Move to the flange on the outside end of the axle and press the axle shaft in towards the differential.

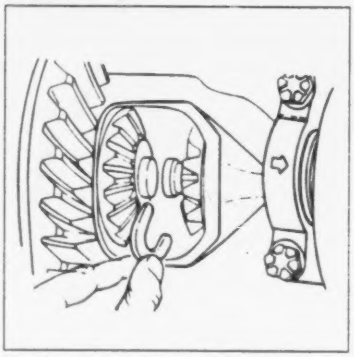
6. Return to the differential case and slide the C-lock out of its groove on the axle shaft. Use pliers if necessary. (Figure 2)

7. Repeat this procedure for the opposite axle.

8. Replace the differential pinion shaft.

9. Replace and tighten the pinion shaft lock bolt.

FIGURE 2



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10. Pull each axle shaft out of the axle housing, being careful not to damage the oil seals or bearings.

CAUTION

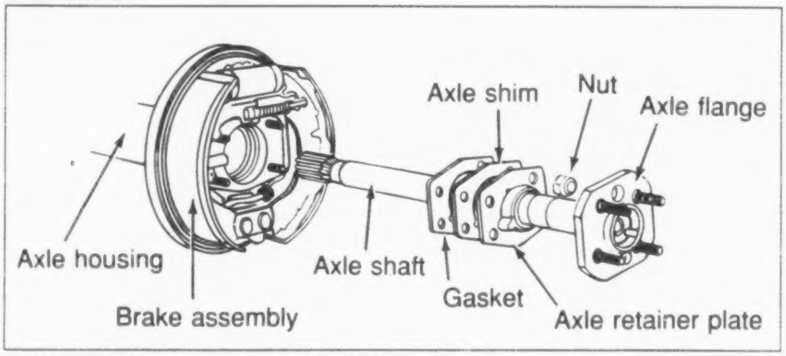
Do not let the axle shaft hang from the axle housing—bearings and seals can be damaged.

11. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

To remove an axle secured by a retainer plate

FIGURE 3


Axle shim
Nut
Axle flange
Axle housing
Axle shaft
Gasket
Brake assembly
Axle retainer plate

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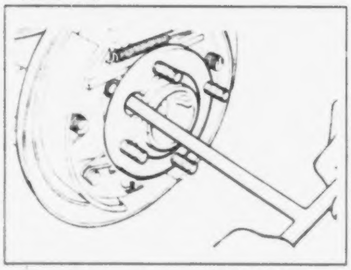
1. Rotate the axle flange so that you can reach the retainer plate nuts through the flange's access hole. (Figure 4)

   NOTE: If there is no access hole in the axle flange, the retainer plate nuts can be removed from the other side of the retainer plate.

FIGURE 4



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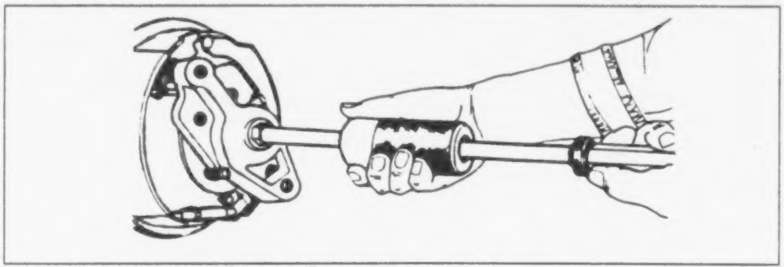
2. Use a socket wrench and extension to unbolt the retainer plate nuts.
3. Pull the axle out of the axle housing, being careful not to damage the oil seals or bearings.
4. If the axle is does not slide out readily, you may have to use a slide hammer with an axle adapter. (Figure 5)

FIGURE 5



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5. Remove the brake backing plate and attach it to the vehicle frame with mechanic's wire.
6. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 3

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13C

Measure ring gear runout.

INTRODUCTION

Ring gear runout is the distance the ring gear moves side-to-side (toward and away from the wheels) while it rotates. Such side-to-side movement can cause noise and damage and excessive wear to differential parts as well as contributing to poor overall operation.

Ring gear runout should always be measured before the differential is removed and disassembled for other testing and service. Ring gear runout can be caused by loose ring gear bolts, worn differential side bearings, a warped or damaged differential case, or a warped ring gear. Taking a measurement before the differential is removed and disassembled will alert the technician to possible problems with these parts.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, Unit 1, ***Using a Dial Indicator***
- Eye protection
- Torque wrench
- Dial indicator
- Pencil and paper

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported and the rear axle lubricant drained. If the vehicle has an integral carrier housing, the housing cover should be removed. (Job Sheet 1) If the vehicle has a removable carrier, the carrier should be removed and installed in a differential holding fixture (Job Sheet 7).

PROCEDURE

Measure ring gear runout

1. Make sure the ring gear bolts are all torqued to the proper specifications.

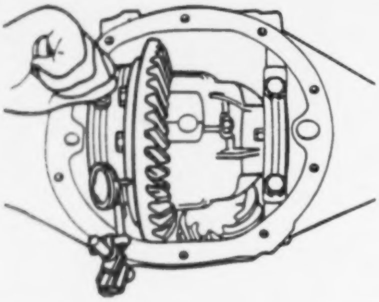
   NOTE: Unevenly torqued ring gear bolts are the simplest cause of ring gear runout. If this step is not performed properly, all other steps will be meaningless.

2. Mount the dial indicator on the axle housing or the differential holding fixture.

3. Position the dial indicator plunger at a right angle to the flat surface on the back of the ring gear. (Figure 1)

   NOTE: There is only a very small area on the back of the ring gear which is not covered by the flange on the differential case.

FIGURE 1



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4. Use the procedure outlined in Supplement 8, Unit 1, "Using a Dial Indicator," to measure the ring gear runout, rotating the ring gear one time to take the measurement.

5. Check the runout measurement against the specifications listed in the vehicle's service manual.

6. If the ring gear runout measurement is not within specifications, inspect the differential side bearings (Job Sheet 10) after removing the differential case from the housing (Job Sheet 7).

7. If the side bearings are damaged or excessively worn, replace them (Job Sheet 10) and measure ring gear runout again.

8. If ring gear runout is still not within specifications after replacing the side bearings, the ring gear or the differential case or both have runout and must be replaced. After the differential is removed from the vehicle, check differential case runout (Job Sheet 9) to see which part is defective.

9. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

OBJECTIVE 13D **Check ring gear tooth contact patterns.**

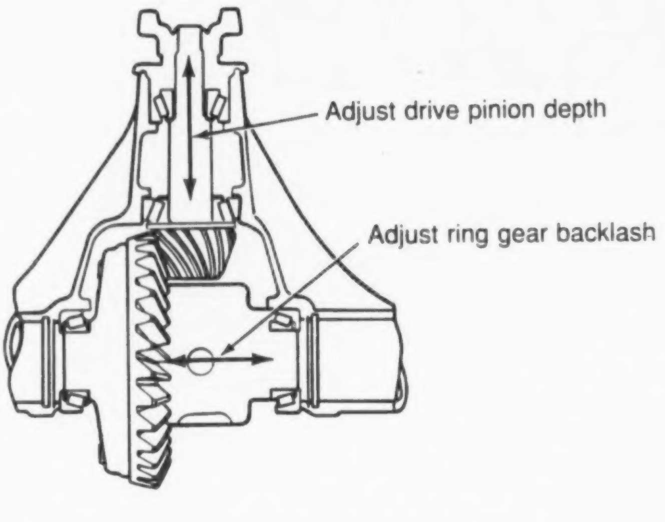
INTRODUCTION

The technician can determine some adjustments the differential will need during servicing by examining the contact patterns left on the ring gear when the ring gear and drive pinion gear mesh. Because such pressure-created patterns are rarely visible under ordinary circumstances, it is necessary that the technician know how to make a ring gear tooth contact pattern test.

A ring gear tooth contact pattern test should be made before the differential is disassembled and any other service performed. The results of the test will tell the technician some of the adjustments that will be necessary during servicing. (Figure 1) After the adjustments and service are completed, a ring gear tooth contact pattern test is made again to make sure all adjustments have been completed correctly.

FIGURE 1

BACKLASH ADJUSTMENTS



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If the ring gear tooth contact patterns are incorrect, the drive pinion and the ring gear are not meshing properly. One of two basic problems usually exists:

- The drive pinion gear is too close or too far away from the ring gear. The drive pinion depth needs to be adjusted.
- The ring gear is too close or too far away from the drive pinion gear. The ring to pinion gear backlash needs to be adjusted.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Objective 11, ***Ring Gear Tooth Contact Pattern Diagnosis Chart***
- Lint-free shop towels
- Gear-marking compound (for example: Nondrying Prussian blue, titanium dioxide, yellow ferric (iron) oxide, artists' oil paint)
- Medium stiff brush
- Torque wrench
- Socket and ratchet
- Shop light

For checking ring tooth contact patterns on a vehicle with a removable carrier, you will also need:

- Large screwdriver or pry bar

NOTE: This job sheet requires the help of an assistant.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be raised and supported safely. The driveline should be removed (Unit 1, Job Sheet 3) and the rear axle lubricant should be drained (Job Sheet 1). In vehicles with an integral carrier axle housing, the rear housing cover should be removed to expose the differential and ring gear (Job Sheet 1). In vehicles with a removable carrier housing, the differential should be removed and installed in a differential holding fixture (Job Sheet 7).

PROCEDURE

Check ring gear tooth contact pattern on a vehicle with an integral carrier housing

1. Use a lint-free shop towel to wipe out the differential area of the axle housing.

2. Clean the lubricant from all differential components.
3. Carefully clean each tooth of the ring gear, removing all lubricant.

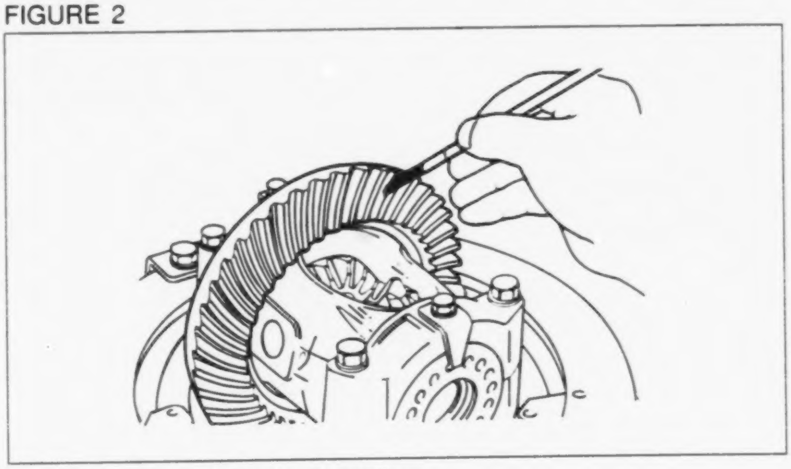
   NOTE: Leaving even the smallest amount of lubricant on the gear teeth will cause smeared test results.

4. Tighten the differential bearing cap bolts to the specified torque.
5. Check the service manual to determine the correct torque load to apply during the ring gear tooth contact pattern test.
6. Place a torque wrench on the drive pinion nut and use it to rotate the drive pinion with a smooth steady motion.
7. Note the torque reading necessary to keep the drive pinion gear rotating.

   NOTE: The correct torque reading is the one necessary to *keep* the drive pinion gear rotating—not the one necessary to *get* the gear rotating.

8. Have your helper gradually engage the parking brake as you continue to rotate the drive pinion gear with the torque wrench.
9. Have the helper stop applying pressure to the parking brake when the recommended torque reading is reached.
10. Brush a *thin* coating of the gear marking compound onto both sides of all ring gear teeth. (Figure 2)

FIGURE 2



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11. Place a socket and ratchet on the drive pinion nut.

12. Use the socket and ratchet to turn the drive pinion slowly and steadily *only one* full rotation in one direction, then *only one* full rotation in the opposite direction.

13. If the ring gear tooth contact pattern does not show up well the first time, reapply the gear marking compound and make the test again.

14. If the contact patterns on one or more teeth vary from the pattern on the other gear teeth, check the ring gear and the drive pinion gear teeth for damage.

15. Use a shop light to examine the contact patterns on the drive side of the ring teeth and compare them to acceptable ring tooth patterns to diagnose needed differential adjustments. (See Objective 11 in the Information Sheet.)

    NOTE: A ring gear in a nonhunting gear set will not have identical patterns on every gear tooth.

16. After adjustments are made, re-test the ring gear tooth contact patterns until an acceptable pattern is reached.

17. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Check ring gear tooth contact pattern on a vehicle with a removable carrier housing

1. Tilt the differential holding fixture so you will be able to rotate the drive pinion nut with a socket and ratchet.

2. Use a lint-free shop towel to clean the lubricant from all differential components.

3. Carefully clean each tooth of the ring gear, removing all lubricant.

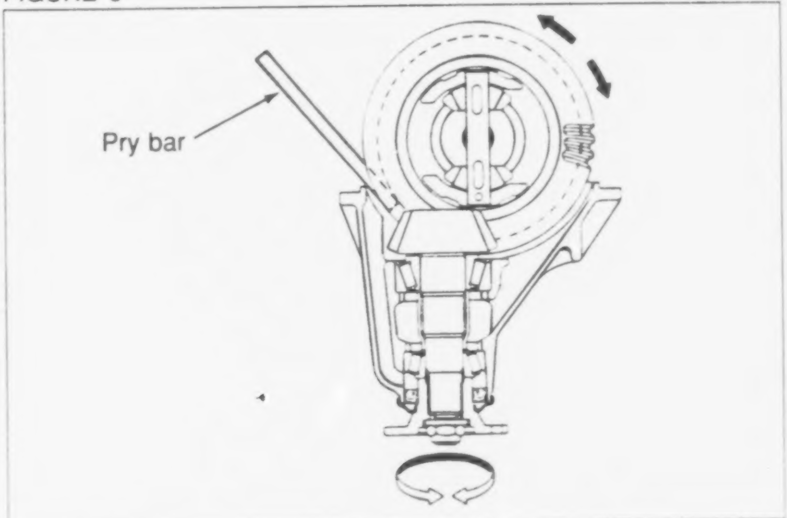
   NOTE: Leaving even the smallest amount of lubricant on the gear teeth will cause smeared test results.

4. Brush a *thin* coating of the gear marking compound onto both sides of all ring gear teeth.

5. Place a large screwdriver or pry bar between the differential case and the outside diameter of the ring gear and use it to apply pressure on the ring gear. (Figure 3)

   NOTE: This will act as a brake to load to the differential during the test.

FIGURE 3



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6. Place a socket and ratchet on the drive pinion nut.

7. Use the socket and ratchet to turn the drive pinion gear slowly and steadily only *one* full rotation in one direction, then only *one* full rotation in the opposite direction.

8. If the ring gear tooth contact pattern does not show up well the first time, reapply the gear marking compound and make the test again.

9. Use a shop light to examine the contact patterns on the drive side of the ring teeth and compare them to acceptable ring tooth patterns to diagnose needed differential adjustments. (See Objective 11 in the Information Sheet.)

   NOTE: A ring gear in a nonhunting gear set will not have identical patterns on every gear tooth.

10. After adjustments are made, re-test the ring gear tooth contact patterns until an acceptable pattern is reached.

11. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 5

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

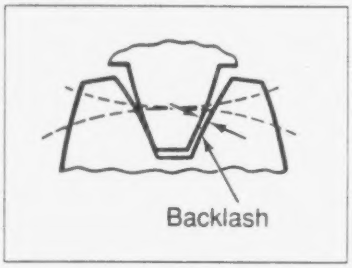
OBJECTIVE 13E

Measure and adjust side bearing preload and ring to pinion gear backlash.

INTRODUCTION

When the teeth on the drive pinion gear and the teeth on the ring gear meet, they should mesh evenly. If there is too much space between the meshed teeth, the condition is called ***ring to pinion gear backlash***. (Figure 1) A ring to pinion gear backlash measurement that is not within specifications can cause noise, damage, and extra wear on differential parts.

FIGURE 1



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Ring to pinion gear backlash should always be measured before the differential is removed and disassembled for other testing and service. If the differential does not need to be removed for any other reason, needed backlash adjustments can be made immediately. However if the differential is removed, ring to pinion gear backlash must be remeasured and needed adjustments made after the differential is replaced in the axle housing.

Side bearing preload is pressure placed on the differential side bearings which helps them control the side-to-side (toward and away from the wheels) movement of the differential case. Some side-to-side movement is inevitable as the vehicle turns corners, but if the differential case moves back and forth excessively, the ring gear and drive pinion gear will not mesh properly.

Adjusting the ring to pinion gear backlash *sets* the operating distance between the ring gear and drive pinion gear. Side bearing preload is the pressure adjustment placed on the differential side bearings which *keeps* the setting constant.

Preload and backlash adjustments are ordinarily made at the same time. There are two main methods of adjusting side bearing preload and ring gear backlash. Some differentials, usually those housed in removable carrier housings, have threaded bearing adjusting nuts on the sides of the differential case. Turning the adjusting nuts adjusts both the side bearing preload and the ring gear backlash. Other differentials use shims and spacers which are added or removed between the differential side bearing and the carrier or housing to increase or decrease the side bearing preload and ring gear backlash.

NOTE: The procedures in this job sheet only apply to vehicles with a conventional differential. Even among vehicles with conventional differentials, there are significant differences in the methods used to adjust side bearing preload and ring gear backlash. Consult the correct service manual to determine how these adjustments are made on the vehicle you are servicing.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, Unit 1, ***Using a Dial Indicator***
- Eye protection
- Dial indicator
- Pencil and paper
- Combination wrenches
- Torque wrench

For a vehicle which uses bearing adjusting nuts to adjust preload and backlash, you will also need:

- Side bearing spanner wrench

For a vehicle which uses shims and spacers to adjust preload and backlash, you will also need:

- Outside micrometer
- Manufacturer-recommended replacement shims and spacers

  NOTE: You will need a variety of sizes of shims to choose from in order to make the correct adjustments.

- Set of feeler gauges
- Shim installer

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported. The rear axle lubricant should be drained (Job Sheet 1), and the driveline removed (Job Sheet 3, Unit 1). If the vehicle has an integral carrier housing, the rear cover should be removed. (Job Sheet 1) If the vehicle has a removable carrier housing, the differential should be removed and installed in a differential holding fixture. (Job Sheet 7)

PROCEDURE

Measure ring to pinion gear backlash

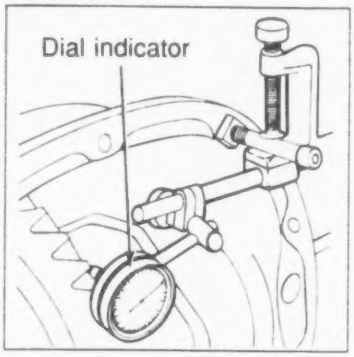
1. Make sure the ring gear bolts are torqued to specification.

2. Install a dial indicator on the axle housing or the differential holding fixture.

3. Position the dial indicator plunger at a right angle to the face of one of the ring gear teeth. (Figure 2)

4. Use the procedures outlined in Supplement 8, Unit 1, "Using a Dial Indicator," to measure ring to pinion gear backlash.

FIGURE 2



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5. Hold the companion flange, making sure the drive pinion gear doesn't move.

6. Rock the ring gear back and forth on its axis until you feel and/or hear the teeth on the ring gear touch the teeth of the drive pinion.

7. Note the indicator reading.

8. Move the indicator plunger off the gear tooth and rotate the ring gear ¼ turn.

9. Repeat the positioning and measurement procedure.

10. Take and note measurements at four places on the ring gear.

11. Check the backlash measurements against the specifications listed in the vehicle's service manual.

12. If the backlash measurements are different at three or four locations around the ring gear, either the ring gear or the differential case has runout—check the differential case runout after the case is removed from the housing.

13. If the backlash measurements are the same at three or four locations around the ring gear, but not within specifications—adjust the side bearing preload and/or the ring gear backlash.

PROCEDURE

Test differential side bearing preload

NOTE: Measure the ring gear runout and the ring to pinion gear backlash before testing the differential side bearing preload.

1. Lay your hand on the outside diameter of the ring gear.

2. Try to rock the ring gear quickly from side to side—any looseness and/or rattling noise indicates insufficient bearing preload.

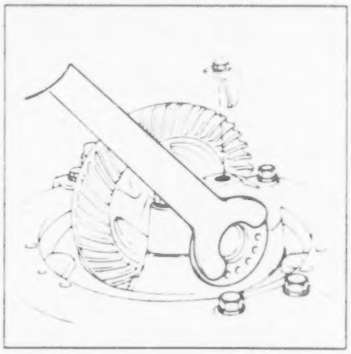
   NOTE: The correct differential side bearing preload has been reached when the ring gear can be moved side to side, but only with considerable difficulty.

PROCEDURE

Adjust differential side bearing preload on vehicles which adjust the preload with adjusting nuts

1. Use an appropriate wrench to remove the adjusting nut locks. (Figure 3)
2. Use a side bearing spanner wrench to tighten both adjusting nuts to increase the side bearing preload. (Figure 3)
3. Loosen both adjusting nuts to decrease the side bearing preload.
4. Retest the side bearing preload until the proper preload has been reached.
5. Replace the adjusting nut locks.

FIGURE 3



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PROCEDURE

Adjust ring to pinion gear backlash on vehicles which adjust backlash with adjusting nuts

1. Use an appropriate wrench to remove the adjusting nut locks.
2. Loosen the side bearing cap bolts.
3. Torque the side bearing cap bolts to specification.
4. Loosen the right adjusting nut (side opposite ring gear).
5. Tighten the left adjusting nut until there is no backlash.
6. Make sure the right nut is still loose.
7. Tighten the right nut two notches beyond where it first contacts the side bearing cap.

8. Rotate the ring gear several revolutions in both directions to seat the bearings.

9. Loosen the right adjusting nut to release the preload.

10. If there is any backlash, tighten the left nut until the backlash is removed.

11. Tighten the right nut two to three notches beyond where it first contacts the side bearing cap.

12. Recheck the torque on the side bearing cap bolts.

13. Recheck the ring to pinion gear backlash.

14. After backlash measurements are brought within specifications, recheck the ring gear tooth contact patterns to insure that all needed adjustments have been made.

15. Reinstall the adjusting nut locks and torque to specification.

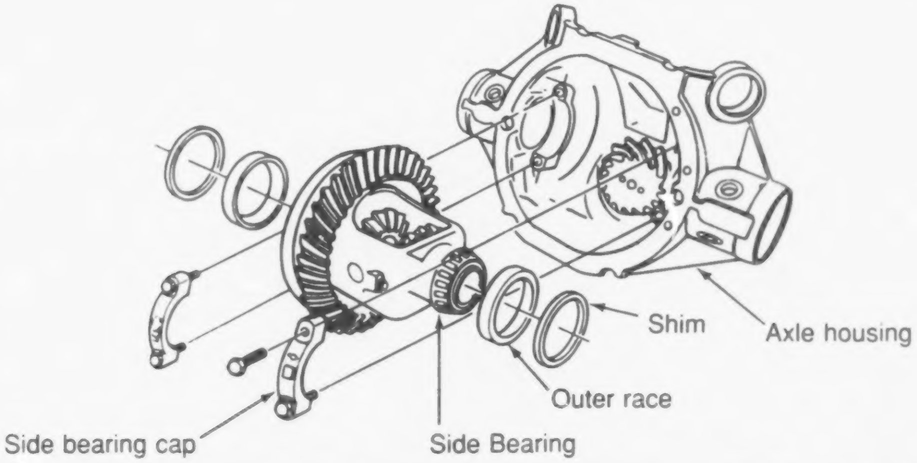
16. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Adjust differential side bearing preload on vehicles which adjust the preload with shims and spacers

1. Remove the side bearing caps from the differential case. (Figure 4)

FIGURE 4



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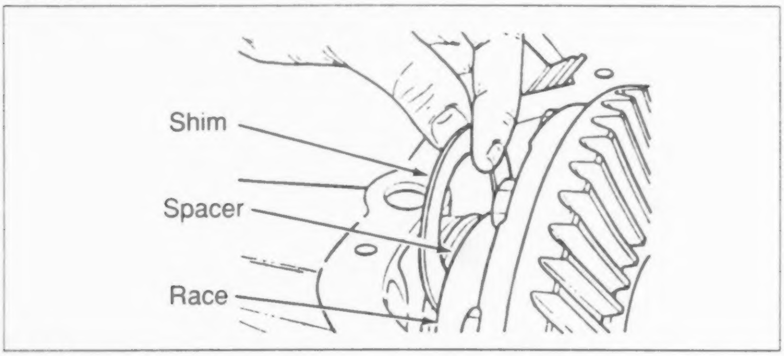
2. Use an outside micrometer to measure the original spacer and shim pack for each side bearing to determine the proper size spacer and shim pack to use in starting backlash adjustments.

3. Install the proper size spacer and shim pack between the bearing and the axle housing on the left (ring gear side) side of the differential case. (Figure 5)

FIGURE 5



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NOTE: Production (original equipment) shims are cast iron and break easily if reinstalled. Use service (replacement) shims made of steel when adjusting side bearing preload and ring gear backlash. Always install shims with their chamfered side *away* from the differential case. (A ***chamfer*** is a beveled groove cut into an outside edge and side of the shim.)

4. Install the left side bearing cap and tighten the bolts with your hand.

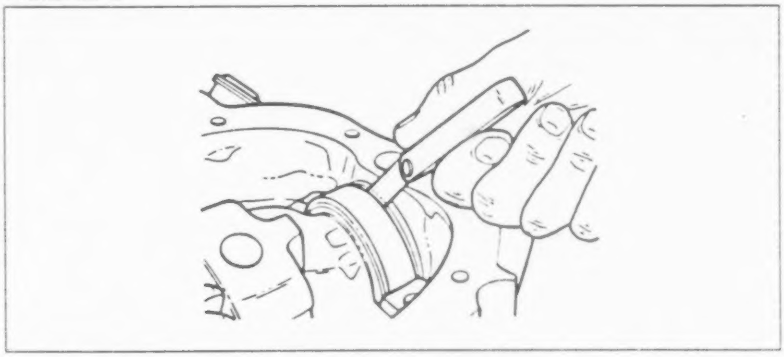
   NOTE: If there is an arrow on the left side bearing cap, make sure it points toward the outside end of the axle housing.

5. Make sure the left spacer and shim pack is positioned against the left side of the axle housing.

6. Install the proper size spacer and shim pack on the right side of the differential case.

7. Work increasingly larger sizes of feeler gauges into the space between the right spacer and shim to measure the additional shim thickness needed. (Figure 6)

FIGURE 6



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8. Push the feeler gauge all the way down until it contacts the housing bore.
9. Notice when there is considerably more drag when positioning the feeler gauge.
10. The correct reading is the one *just before* the noticeable increase in drag.
11. Remove the side bearing caps, spacers, and shim packs from the carrier, making sure that the parts for the left and right sides are kept separate.
12. Select two shims of as nearly equal size as possible whose total width equals the thickness of the correct feeler gauge measurement.
13. Add one of these shims to each shim pack.
14. If the drive pinion gear is in position, reinstall the ring gear following outlined procedures (Job Sheet 8).
15. Make ring gear backlash adjustments as needed.

PROCEDURE

Adjust differential ring gear backlash on vehicles which adjust backlash with shims and spacers

1. Install the spacers and shim packs you selected during the preload adjustment process between the side bearing and the axle housing on both sides of the differential case.

   NOTE: Make sure the spacers and shims are installed on the correct side.

2. Install the side bearing caps and torque the cap bolts to specifications.

3. Rotate the ring gear several revolutions in both directions to seat the bearings.

4. Recheck ring gear backlash following procedures outlined at the beginning of this job sheet.

5. If the backlash measurements are within specifications, recheck the ring gear tooth contact patterns to insure that all needed adjustments have been made.

6. If the backlash measurements are not within specifications, adjust the shims.

7. To decrease the backlash, decrease the thickness of the right shim and increase the thickness of the left shim by equal amounts.

8. To increase the backlash, decrease the thickness of the left shim and increase the thickness of the right shim by equal amounts.

   NOTE: When you add shim thickness to one side, subtract an equal amount from the other side. This maintains the correct side bearing preload.

9. When the backlash is adjusted within specifications, remove the side bearing caps, the spacers, and the shim packs, keeping right and left packs together.

10. Remove one shim from the left shim pack and replace it with one that is .10mm (.004") thicker.

11. Install the left shim pack between the spacer and the left bearing race.

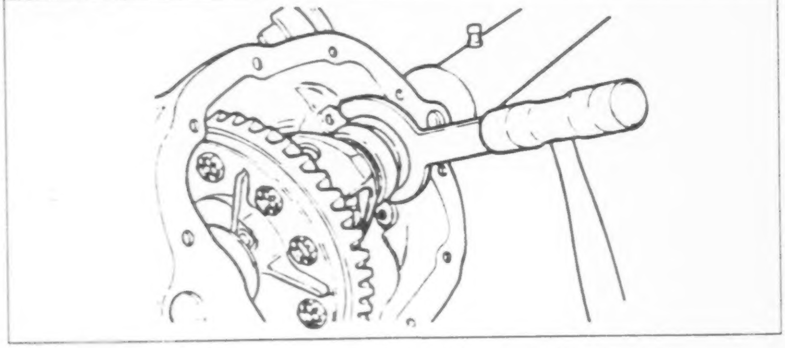
12. Loosely install the left bearing cap.

13. Remove one shim from the right shim pack and replace it with one that is .10mm (.004") thicker.

14. Install the right shim pack between the spacer and the right bearing race.

    NOTE: You will have to drive the right shim into position with a shim installer. (Figure 7)

FIGURE 7



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15. Install the right side bearing cap and torque cap bolts on both side bearing caps to the correct torque.

16. Recheck backlash and correct if necessary.

17. If the backlash measurements are different at three or four locations around the ring gear, the ring gear has runout—replace the ring and drive pinion gear set.

18. After backlash measurements are brought within specifications, recheck the ring gear tooth contact patterns to insure that all needed adjustments have been made.

19. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 6

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13F

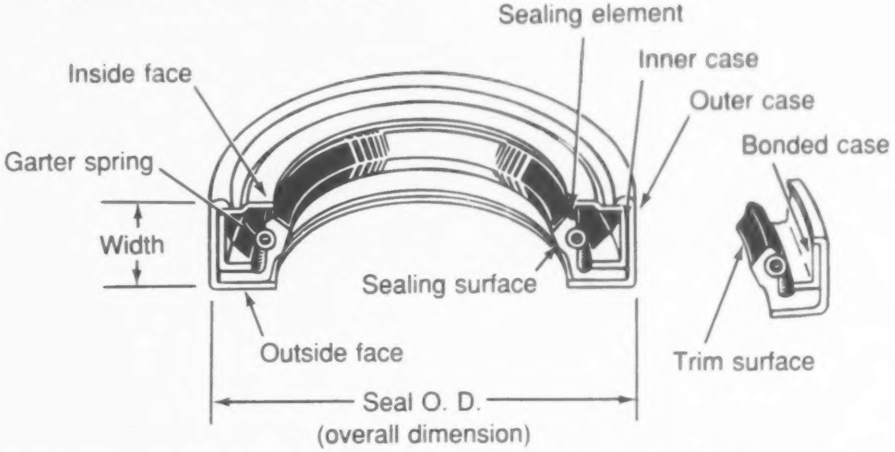
Remove, inspect, and replace a companion flange and pinion seal.

RADIAL LIP SEALS

A pinion seal, a type of **radial lip seal**, is a precision assembly made of metal and synthetic rubber. A circular spring imbedded in the seal's rubber sealing surface helps hold the seal snug against the drive pinion shaft.

The purpose of the pinion seal is to keep the rear axle lubricant contained in the appropriate area. Oil seals have an ***inside*** and an ***outside*** surface (see below). The seal's *inside* face should always face the rear axle lubricant or the seal will leak.

Pinion seals and rear axle shaft oil seals are replaced as a matter of routine whenever the drive pinion or rear axles are removed. It is less expensive to replace the seals than to reinstall the old seals and risk having to remove the axles again if the old seals should fail. Check the vehicle's service manual to find the correct part number for the seal that you are replacing.



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INTRODUCTION

If there is companion flange damage or runout, the companion flange must be replaced. If the pinion seal has been removed for any reason, or if there is a lubricant leak at the companion flange due to a worn or damaged pinion seal, a new pinion seal must be installed. These procedures are performed with the differential and the drive pinion gear assembly installed in the axle housing.

Occasionally, the companion flange and/or pinion seal are replaced even though no other service is performed on the differential or rear axle. In theory, it is possible to replace the companion flange and pinion seal without removing the entire differential case and drive pinion assembly. However, after they are reinstalled, care must be taken to assure that both the drive pinion bearing preload and the drive pinion depth are set properly. In fact, this is very difficult to do and more often than not, the differential case and drive pinion assembly must be removed from the axle housing, and the collapsible spacer in the drive pinion gear assembly replaced so the pinion bearing preload and drive pinion depth can be properly set.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Drain pan
- Shop towels
- Pencil and paper
- Companion flange holding tool
- Companion flange remover or jawed puller
- Socket and ratchet
- Permanent marker or sharp awl to make matchmarks
- Heavy screwdriver
- Crocus cloth
- Replacement pinion seal and companion flange washer
- Replacement companion flange and nut as required
- Beam-type torque wrench
- Rear axle lubricant
- Pinion seal installation tool

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported with the driveline removed (Job Sheet 3, Unit 1).

PROCEDURE

Remove the companion flange and pinion seal

1. Place a beam-type torque wrench on the pinion nut and slowly and steadily rotate the drive pinion several times to measure the drive pinion bearing preload.

2. Record the torque measurement.

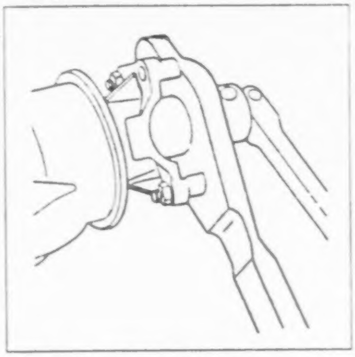
   NOTE: The correct torque reading is the one which *keeps* the drive pinion rotating, not the reading which *starts* the drive pinion rotating. If very little torque is necessary to rotate the drive pinion, this indicates that there is little or no preload on the drive pinion bearing. Shake the companion flange to check for looseness. Looseness is caused by worn drive pinion bearings and/or a worn companion flange. If the vehicle has been operated in this condition for any length of time, the ring gear and drive pinion gear will most likely be damaged and require replacement.

3. If the companion flange is to be reinstalled rather than replaced, make matchmarks on the companion flange and the drive pinion shaft so they can be reinstalled in the same position.

4. Hold the companion flange with a companion flange holding tool and use a socket and ratchet to remove the pinion nut and washer. (Figure 1)

   NOTE: All-metal pinion nuts or castle-type nuts used with a cotter pin can be reused. However, manufacturers recommend that pinion nuts be replaced.

FIGURE 1



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5. Use a companion flange remover or jawed puller to remove the companion flange. (Figure 2)

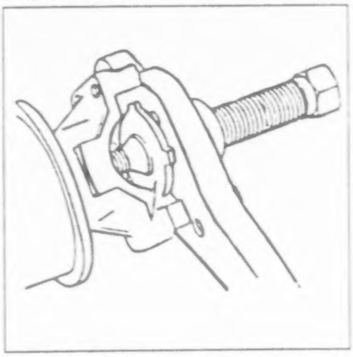
6. Clean the area around the oil seal with a shop towel.

7. Place a drain pan under the oil seal area to catch any lubricant.

8. Use a heavy screwdriver to pry the pinion seal out of the differential housing.

   NOTE: The old pinion seal will not be reused.

FIGURE 2



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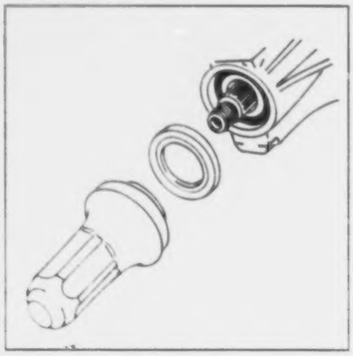
PROCEDURE

Inspect and install a pinion seal and companion flange

1. Use a shop towel to clean the inside of the housing bore where the pinion seal will be installed and inspect it for damage or burrs.
2. Clean the pinion shaft splines and inspect them for damage or burrs.
3. If the companion flange is to be reinstalled, inspect it for damage or burrs.
4. Use a crocus cloth to remove any burrs from the companion flange, pinion shaft splines, and the seal seating surface inside the axle housing.
5. Check the replacement seal and companion flange to make sure they conform to manufacturer specifications.
6. Place a thin coat of rear axle lubricant on the inside of the axle housing bore and the outside edge and sealing lip of the replacement seal.
7. Use the proper seal installation tool to install the pinion seal, making sure it is positioned squarely in the housing bore. (Figure 3)
8. Place a thin coat of rear axle lubricant on the sealing surface and the outside diameter of the new or replacement companion flange.

FIGURE 3



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9. Install the companion flange, using a new washer and a new pinion nut (if appropriate).

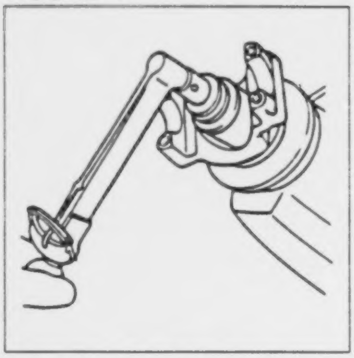
   NOTE: If the washer is collapsible, make sure the rounded side is on the outside.

10. Hold the companion flange with the companion flange holder and use a socket and ratchet to tighten the pinion nut *a little at a time*.

11. After each tightening, turn the drive pinion several revolutions to set the rollers and then check the drive pinion bearing preload with a torque wrench. (Figure 4)

12. Tighten the pinion nut until the torque is set 0.3-0.6 N m (3-5 lb.in.) more than the torque reading measured on the pinion nut when it was removed.

FIGURE 4



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13. Check the ring gear tooth contact pattern. (Job Sheet 4)

    NOTE: The torque reading for the pinion bearing preload should be within specifications, and the ring gear tooth contact test should show acceptable tooth patterns. If the results of either of these tests are unacceptable, the differential case and drive pinion assembly will have to be removed from the axle housing, the drive pinion collapsible spacer replaced, and the drive pinion preload reset. (See Job Sheets 7, 13, 14, 15, and 16.)

14. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 7

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES II

OBJECTIVE 13G

Remove the differential case assembly and clean and inspect the differential housing.

INTRODUCTION

Some differential and rear axle service can be completed without removing the differential from the axle housing or carrier. However, service involving parts of the drive pinion assembly or parts contained in the differential case assembly requires that the differential case be removed. In the case of vehicles with an integral carrier housing, the differential case is removed directly from the axle housing. If the vehicle has a removable carrier housing, the carrier must be removed from the axle housing before the differential case can be removed from the carrier.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Allen, combination, or socket wrenches
- Permanent marker or sharp awl to make matchmarks
- Differential spreader tool (if suggested by manufacturer)
- Pry bar
- Soft-faced mallet
- Mechanic's wire
- Workbench
- Shop towels
- Putty knife
- Approved cleaning solvent
- Stiff brush
- Stiff wire or coat hanger
- Emery cloth or half-round mill file

For a vehicle with a removable carrier housing, you will also need:

- Wire brush
- Hoist stand
- Drain pan
- Differential holding fixture or bench vise

NOTE: The carrier assembly on a removable carrier housing is extremely heavy. You will need an assistant to help you remove the carrier from a removable carrier housing.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported, and the rear axle lubricant drained (Job Sheet 1). The rear wheels, brake drums, rear axle shafts (Job Sheet 2), and driveline (Job Sheet 3, Unit 1) should be removed. If it is the manufacturer's recommendation, check rear axle end play before removing the differential (Job Sheet 21).

PROCEDURE

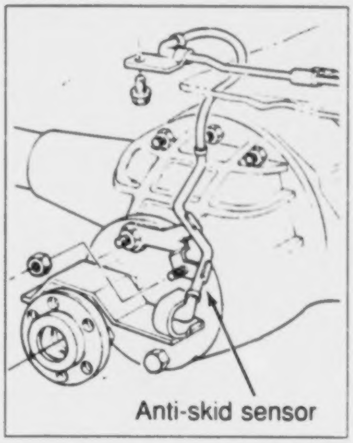
Remove the carrier from a removable carrier housing

1. Clean the outside of the housing with a wire brush.

   NOTE: If you need to steam clean the outside of the axle housing, do this before you remove the carrier cover.

2. Use a shop towel and approved cleaning solvent to clean the seam where the carrier connects with the axle housing.

FIGURE 1



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3. If the vehicle's braking system uses an anti-skid sensor, unplug it from the carrier. (Figure 1)

4. If you have not drained the lubricant from the carrier housing, place a drain pan under the seam on the removable carrier.

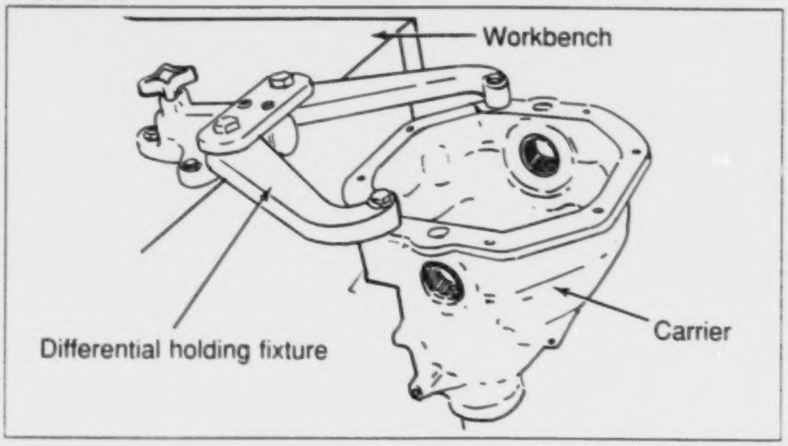
5. Position a hoist stand under the carrier portion of the housing to support the carrier when it is removed.

6. Have an assistant help hold the carrier steady while you use a wrench to remove the nuts, bolts, and washers that hold the carrier to the housing.

7. Have your assistant help you remove the carrier from the axle housing.

8. Install the carrier in a differential holding fixture or mount it securely in a bench vise. (Figure 2)

FIGURE 2



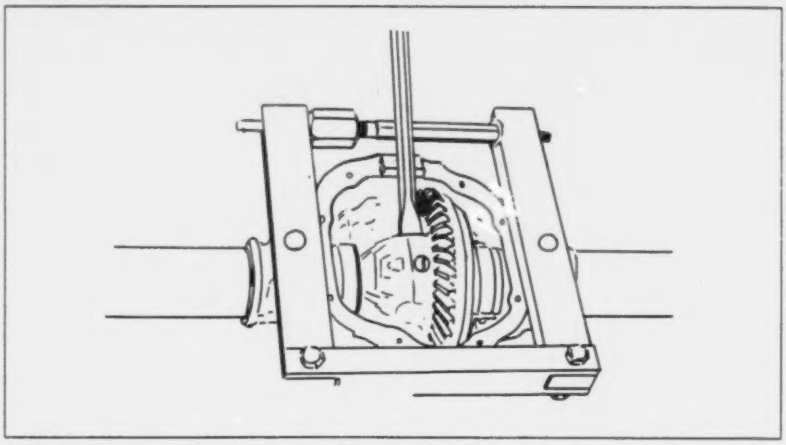
PROCEDURE

Remove the differential case assembly

NOTE: The procedures for removing the differential case from an integral carrier housing or the carrier section of a removable housing are essentially the same.

1. Make sure the following checks and measurements have been made *before* removing the differential case from the axle housing or carrier.
   - Check ring gear tooth contact patterns
   - Measure ring gear runout
   - Measure ring gear backlash
   - Check differential side bearing preload
2. Make sure you have replaced the pinion shaft lock bolt if you removed it when removing an axle secured by C-locks.
3. If you are removing a differential case from an integral carrier housing, the manufacturer may recommend the use of a differential spreader tool. If so, mount the tool on the holes on either side of the differential housing and turn the adjuster screw to spread the housing slightly. (Figure 3)

FIGURE 3



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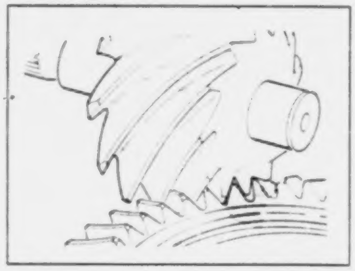
4. If the differential side bearing caps are not marked "left" and "right," mark them so they can be reassembled in the same position.

5. If the ring gear and drive pinion gear are a nonhunting gear set, mark one drive pinion gear tooth and the two ring gear teeth on either side of it with a permanent marker or paint so that the gears can be reassembled in the same position. (Figure 4)

FIGURE 4



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NOTE: Check the differential identification code and the service manual to find out if the gear set is a nonhunting set; or count the number of ring gear teeth and the number of drive pinion gear teeth. Divide the number of drive gear teeth into the number of ring gear teeth. If the result is a whole number rather than a decimal (or fraction), the gear set is a ***nonhunting*** gear set—mark the gear teeth.

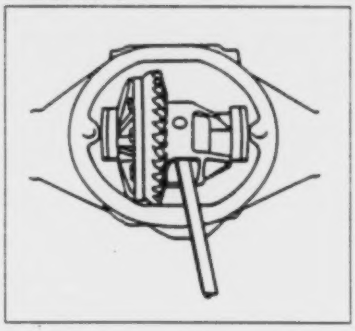
6. Use an appropriate wrench to loosen the side bearing cap bolts until they are held in place by only a few threads but leave the bearing caps in place to hold the differential in the housing until it is loosened.

7. Put a pry bar behind the differential case and pry the case forward. (Figure 5)

CAUTION

Do not allow the pry bar to damage the gasket sealing surface on the axle housing—put a couple of shop towels on the edge of the sealing surface to protect it.

FIGURE 5



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CAUTION

The differential case will be held tightly in the differential housing until it is moved past a certain point, then it will suddenly come loose. Do not be caught off guard by this sudden release.

8. Hold the differential case in place against the bearing caps.
9. Remove the bearing cap bolts.
10. Carefully remove the side bearing caps, side bearing outer races, and adjusting nuts or shims and spacers, being sure to keep the parts from the left and right sides together in separate piles.

    NOTE: You may have to tap the bearing caps with a soft-faced mallet to loosen them.
11. Loop a piece of mechanic's wire around the parts from each side of the case to hold them together.
12. Remove the differential case and place it on a workbench.

PROCEDURE

Clean and inspect the differential housing

1. Use a shop towel to clean old lubricant and metal flakes from the inside of the removable carrier or differential housing.
2. Use a putty knife to remove all old gasket material from the mating surfaces of the carrier and axle housing (removable housing) or the axle housing and housing cover (integral housing).
3. Use an approved cleaning solvent and a stiff brush to clean the carrier or housing inside and out.

4. Use a stiff wire, such as a coat hanger with a shop towel attached, to swab out the axle bores.

5. Wipe the carrier/housing surfaces with a shop towel and cleaning solvent.

6. If needed, steam clean the outside of the housing to remove grease and grit.

   NOTE: Do not steam clean differential components, axle housing bores or other smooth polished surfaces.

7. Examine the outside of the carrier or housing for cracks, broken welds, casting porosity, or other damage.

   NOTE: If there are leaks from casting porosity, peen the porous area with body lead and finish off with an epoxy sealer. For large pockets of porosity, drill a shallow hole and install a set screw, then finish off with epoxy sealer.

8. If the housing is cracked or has broken welds, replace the housing.

9. Examine the inside of the carrier or housing for wear or damage, paying particular attention to the housing bores where the side bearings and drive pinion seal and bearings are installed.

10. Use an emery cloth or a half-round mill file to smooth burrs on the metal.

11. If the housing is damaged or worn it should be replaced.

12. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 8

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13H

Remove, inspect, and replace a ring gear.

INTRODUCTION

The ring gear does not always need to be removed when other parts of the differential are serviced. However, if ring gear runout is not within specifications, the ring gear should be removed so you can check the differential case runout to determine which part needs to be replaced. If your inspection of the ring gear shows evidence of wear or damage, the ring gear should be removed and replaced.

EQUIPMENT AND MATERIALS

- Differential case with ring gear still installed
- Appropriate service manual
- Eye protection
- Bench vise
- Shop towels
- Combination wrenches
- Permanent marker or sharp awl
- Soft-faced mallet
- Blunt chisel or punch
- Hammer
- Bristle brush
- Approved cleaning solvent
- Shop light
- Crocus cloth
- Whetstone or other knife-sharpening stone
- Arbor press, if needed
- Pilot bolts, if needed
- Thread-locking compound, if needed
- Replacement ring gear bolts
- Torque wrench

> **CAUTION**
> **Always** check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case containing the ring gear should be removed from the axle housing (Job Sheet 7).

PROCEDURE

Remove the ring gear

1. Place the differential case, with the ring gear attached, securely in a bench vise.

2. Use a permanent marker or sharp awl to make matchmarks on the differential case and the ring gear so they can be reassembled in their original positions.

3. Use an appropriate wrench to remove the ring gear bolts.

   NOTE: These bolts may have left-hand threads. If so, turn them clockwise to loosen them.

4. Remove the ring gear.

5. If the ring gear cannot be removed easily, rethread two ring gear bolts to ring gear studs on opposite sides of the gear.

   NOTE: These bolts will keep the ring gear from falling off and becoming damaged as you loosen the ring gear from the differential case.

6. Use a soft-faced mallet or a blunt chisel and hammer to tap, first on one side then on the opposite side, at several locations around the back edge of the ring gear to loosen the gear from the differential housing.

   CAUTION

   Do not pry the ring gear away from the differential case—it will damage it. Do not allow the ring gear to fall or otherwise damage the gear face.

7. Discard the ring gear bolts—they will not be reused.

8. If the ring gear will not come off using this method, use an arbor press to press it off.

PROCEDURE

Inspect the ring gear

1. Use a bristle brush and approved cleaning solvent to clean the ring gear thoroughly.

2. Allow the gear to air dry.

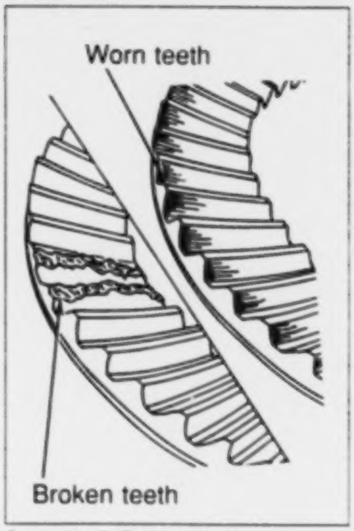
3. Use a shop light to examine the ring gear teeth for scoring, breaking, or excessive wear. (Figure 1)

   NOTE: Gear scoring can be caused by excessive ring gear backlash or using the wrong kind or too little lubricant.

4. Examine the rest of the ring gear for burrs, wear, or damage.

5. Remove burrs with a crocus cloth.

FIGURE 1



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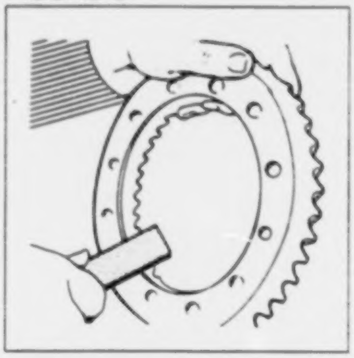
6. If the inside edge of the gear is sharp, smooth it with a whetstone or knife-sharpening stone. (Figure 2)

7. If sharp edges or burrs are removed, clean the gear to remove abrasive particles that may remain.

8. Replace the gear if there is any wear or damage.

FIGURE 2



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PROCEDURE

Replace the ring gear

NOTE: Before you replace the ring gear, check the differential case runout to make sure it is within specifications. (Job Sheet 9) Also check the results of the ring gear runout measurement to insure that the ring gear being replaced is within runout specifications. The parts inside the differential case should be reinstalled before replacing the ring gear. (Job Sheet 11)

1. Make sure the differential case is clean and has been checked for burrs or damage.

2. Align the matchmarks on the ring gear and the differential case.

3. Fit the ring gear on the differential case.

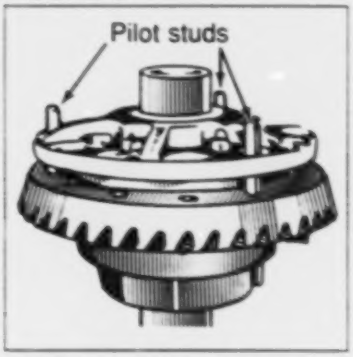
   NOTE: It may be necessary to tap the ring gear with a soft-faced mallet to seat it against the differential case.

4. If necessary, use pilot bolts to align the gear and the case. (Figure 3)

5. Thread two *new* ring gear bolts on opposite sides of the case and tighten them snugly.

   NOTE: Never reuse old ring gear bolts. If the new bolts are not coated, apply thread-locking compound to the threads before installing them.

FIGURE 3



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6. Torque the ring gear bolts in a star pattern to tighten the ring gear evenly against the differential case.

7. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 9

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13 I

Measure differential case runout.

INTRODUCTION

If the ring gear runout measurement made before removing the differential case from the housing was not within the manufacturer's specifications, and you have checked to make sure the differential side bearings are sound, either the ring gear or the differential case has excessive runout. After removing the differential case from the axle housing, you should remove the ring gear and measure differential case runout. This test will tell you whether it is the ring gear or the differential case which is defective.

If the differential case runout exceeds specifications, the case must be replaced. However, if your test shows the differential case runout is within specifications, and the ring gear runout was excessive, it is the ring gear that is defective and must be replaced. If the runout problem is not solved by replacing a defective differential case, replace the ring gear as well. If the problem persists, there could be damage to the axle housing.

EQUIPMENT AND MATERIALS

- Differential case
- Approved service manual
- Supplement 8, Unit 1, ***Using a Dial Indicator***
- Eye protection
- Shop towels
- Approved cleaning solvent
- Dial indicator
- V-blocks
- Pencil and paper

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case should be removed from the axle housing (Job Sheet 7), and the ring gear removed (Job Sheet 8). It doesn't matter whether other parts of the differential assembly are still installed or not.

PROCEDURE

Measure differential case runout

1. Clean the outside of the differential case with a shop towel and approved cleaning solvent.

2. Inspect the side of the differential case flange which mates with the ring gear for any burrs, nicks, or damage.

3. Place the differential case on the V-blocks with each side bearing or bearing hub resting solidly on one of the V-blocks.

   NOTE: If the side bearings are still attached to the differential case, make sure they are in good condition and rotate smoothly.

4. Install the dial indicator on the V-blocks or some other unmovable surface.

5. Position the indicator plunger so that it rests at a right angle to the differential case flange near the outer edge of the flange face.

6. Use the procedure outlined in Supplement 8, Unit 1, "Using a Dial Indicator," to measure the differential case runout.

7. Check the runout measurement against the specifications listed in the vehicle's service manual.

8. If the differential case runout exceeds specification, replace the differential case.

9. If the original ring gear runout measurement exceeded specification, but the differential case runout is within specification, replace the ring gear.

   NOTE: The ring gear and drive pinion gear are *always* replaced as a set.

10. When the new part comes in, install it and recheck ring gear runout.

11. If a new differential case has been installed, and runout is still excessive, replace the ring gear and recheck runout with this new part as well.

12. If a new ring gear has been installed, and runout is still excessive, recheck the torque on the ring gear bolts, the condition of the side bearings, and differential case runout.

13. If the cause of the excessive ring gear runout is not found, consider the possibility that the axle housing may be damaged.

14. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 10

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

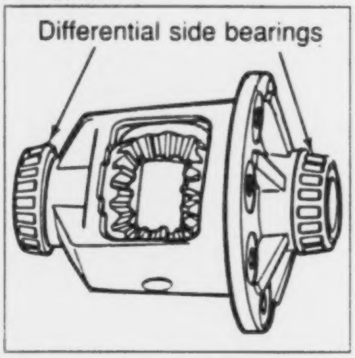
OBJECTIVE 13J

Remove, inspect, and replace differential side bearings.

INTRODUCTION

The differential side bearings (Figure 1) allow the differential case to rotate in the axle housing as the drive pinion gear drives the ring gear. As with other pressed-on bearings, an effort should be made to inspect the differential side bearings without removing them from the differential case. However when the side bearings must be removed, they can usually be removed with a bearing puller and installed with a bearing installation tool. An arbor press may be used if the bearings prove difficult to remove or install.

FIGURE 1



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EQUIPMENT AND MATERIALS

- Differential case with ring gear still installed
- Appropriate service manual
- Supplement 5, ***Cleaning, Inspecting, and Lubricating Antifriction Bearings***
- Supplement 6, ***Tapered Roller Bearing Damage Diagnosis Chart***
- Eye protection
- Bench vise
- Combination wrenches
- Side bearing spanner wrench
- Bearing puller
- Bristle brush
- Approved cleaning solvent
- Crocus cloth
- Rear axle lubricant
- Bearing installation tool
- Hammer

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case should be removed from the axle housing (Job Sheet 7).

PROCEDURE

Inspect the differential side bearings

1. Check the differential side bearings to make sure they fit tightly against the hub on the differential case.

   NOTE: If the bearings do not fit tightly, replace them with new bearings.

2. If the side bearings are adjusted by adjustment nuts, rotate the nuts to make sure they move freely.

   NOTE: If the adjuster nuts do not move freely, repair their threads or replace the nuts.

3. Use a bristle brush and an approved cleaning solvent to clean the adjustment nuts and examine them and the adjustment nut locks for damage or wear.
4. Use a crocus cloth to smooth any nicks or burrs.
5. Wash and dry the bearings using the procedures in Supplement 5, "Cleaning, Inspecting, and Lubricating Antifriction Bearings."
6. Examine the bearing rollers for damage, using Supplement 6, "Tapered Roller Bearing Damage Diagnosis."
7. If the adjustment nuts, adjustment nut locks, or bearings have even the slightest damage or wear, discard the part and replace it.

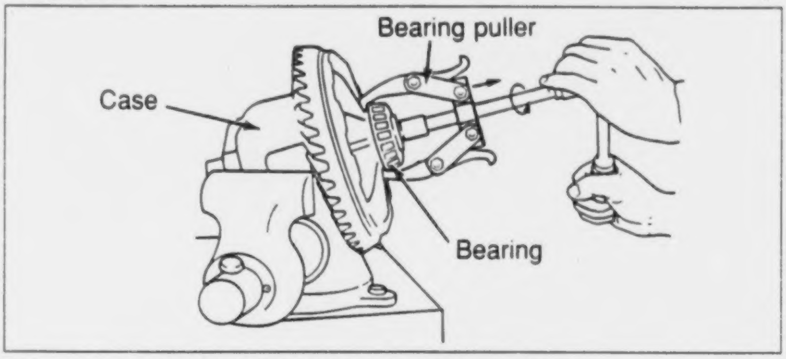
PROCEDURE

Remove the differential side bearings

1. Place the differential case securely in a bench vise.
2. If the bearings are to be replaced, mark them so they can be replaced on the side of the case in their original position.
3. If the side bearings are adjusted with adjuster nuts, use an appropriate wrench to remove the adjuster nut locks.
4. Unscrew the adjuster nuts with a side bearing spanner wrench and remove them.
5. Use a bearing puller to remove the differential side bearing from the differential case. (Figure 2)

   NOTE: Make sure the puller pulls on the bearing cone not on the bearing cage or the cage will be damaged.

FIGURE 2



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6. Reverse the position of the differential case in the vise.

7. Remove the other differential side bearing.

PROCEDURE

Replace the differential side bearings

1. Examine the hubs and bearing shoulders of the differential case where the side bearings will be mounted to make sure they are smooth and free of nicks, burrs, and damage.

2. Use a crocus cloth to remove burrs.

3. Apply a thin coat of rear axle lubricant to the bore of the side bearing cone and the hub and shoulder of the differential case.

4. Place the differential case on a workbench, resting on one differential case hub.

5. If you are reinstalling the same differential side bearings you took off, make sure you install the bearings on the side of the differential housing and in the position in which they were originally installed.

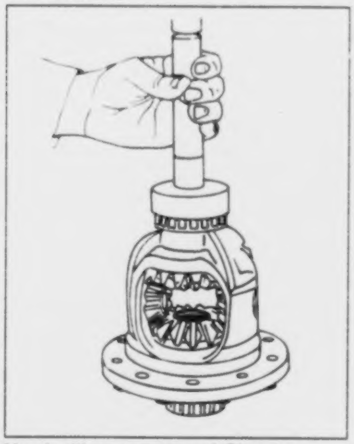
6. Place the side bearing cone on the other differential case hub, with the smaller face towards the outside.

7. Position a bearing installation tool squarely over the side bearing and use a hammer to drive the bearing snug against the shoulder of the differential case. (Figure 3)

8. Turn the differential case over and install the other differential side bearing in the same way.

9. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

FIGURE 3



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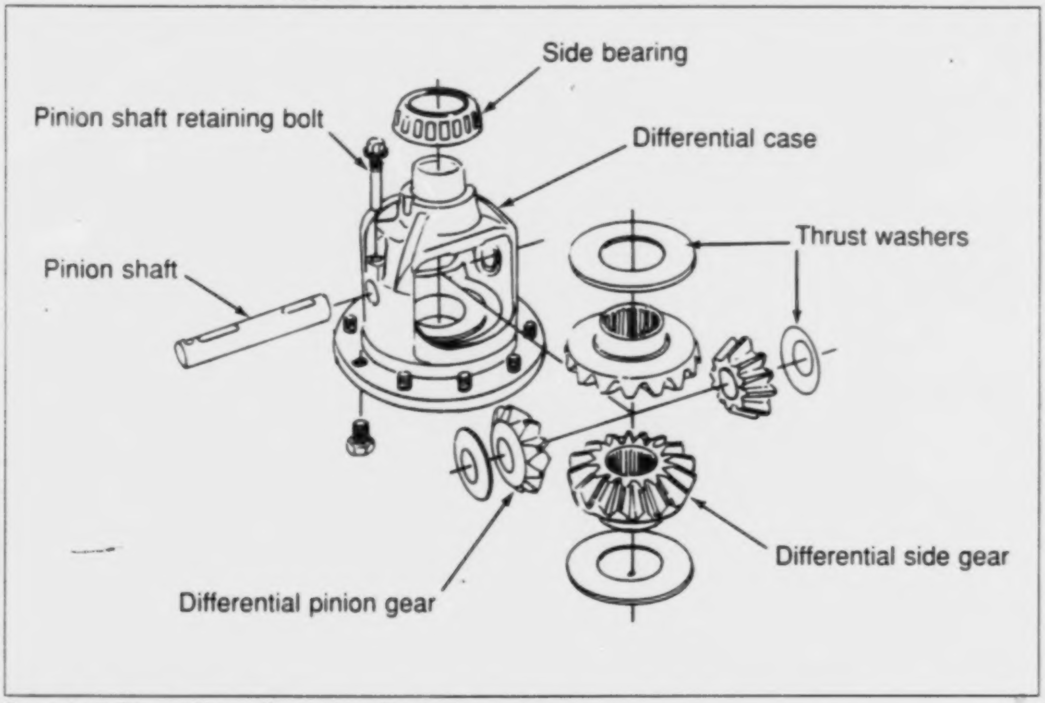
JOB SHEET 11

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13K **Remove, inspect, measure, adjust, and replace the parts of a conventional differential case assembly.**

FIGURE 1


Side bearing
Pinion shaft retaining bolt
Differential case
Thrust washers
Pinion shaft
Differential side gear
Differential pinion gear

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INTRODUCTION

Differential and rear drive axle diagnosis will sometimes indicate that parts of the differential case assembly need to be inspected and/or replaced. If any one part is worn or damaged, all parts of the assembly should be inspected. Fortunately, inspecting all the parts when one is defective takes very little extra effort because it is almost impossible to remove only *one* part of the differential assembly without having all the parts come out—whether you want them to or not. If the differential has been operating with a loss of lubricant, all parts of the differential assembly should be carefully inspected. They will most likely have to be replaced.

This job sheet will not address the removal and inspection of the ring gear and side bearings. For those tasks, see Job Sheets 8 and 10. The special tasks involved in removal and service of limited-slip differentials are covered in Job Sheet 12.

EQUIPMENT AND MATERIALS

- Conventional differential case with assembly parts still installed
- Appropriate service manual
- Eye protection
- Bench vise
- Axle shaft for the differential being used
- Permanent marker or sharp awl
- Shop towels
- Allen or combination wrenches
- Soft-faced mallet
- Brass drift
- Hammer
- Approved cleaning solvent
- Bristle brush
- Rear axle lubricant
- Low-pressure air nozzle
- Crocus cloth

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case should be removed from the axle housing (Job Sheet 7), and the ring gear (Job Sheet 8) and the differential side bearings (Job Sheet 10) should already be removed from the differential case.

PROCEDURE

Measure and remove the parts of a conventional differential case assembly

1. Place the differential case securely in a bench vise.
2. Mesh the splined end of an axle shaft with a side gear and use the axle shaft to rock the differential side gears back and forth against the pinion gears.
3. If there is more than the slightest play between the gears, the pinion to side gear backlash will have to be adjusted during reassembly.
4. Mark the differential case, the differential pinion gears and their thrust washers, and the differential side gears and their thrust washers so they can be replaced in their original positions when they are reassembled.
5. Wipe off the pinion shaft lock bolt with a shop towel.

6. Use an appropriate wrench to carefully remove the differential pinion shaft lock bolt.

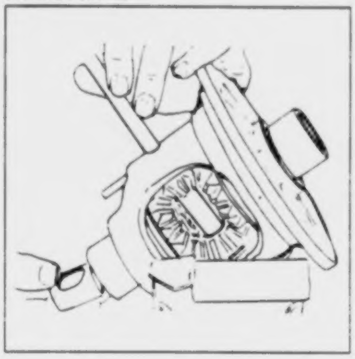
CAUTION

Differential pinion shaft lock bolts break easily.

7. If needed, use a brass drift and hammer to carefully tap the end of the pinion shaft, driving it from the differential case. (Figure 2)

   NOTE: If there is any looseness between the pinion shaft and the differential case, the differential pinion shaft (and possibly the differential case itself) may have to be replaced. Wear between these parts is usually caused by fast starts and stops.

FIGURE 2



8. If the differential case is separable, separate the differential carrier halves and remove the parts of the case assembly.

9. If the differential case is not separable, rotate the differential side gears, rolling out the differential pinion gears and their thrust washers.

CAUTION

Thrust washers, particularly worn ones, can be very sharp.

10. Remove the differential side gears and their thrust washers.

PROCEDURE

Inspect differential case assembly parts

1. Use a bristle brush and appropriate cleaning solvent to clean the differential case and all assembly parts thoroughly.

2. Air dry or blow dry with a low-pressure air nozzle.

3. After drying, apply a thin coat of rear axle lubricant to all parts.

4. Inspect the entire differential case for cracks, nicks, burrs, or other damage

5. If the differential case is separable, check the flange faces and the bolts that hold the two case halves together for damage or wear.

6. Examine the pinion gear and side gear bores in the differential case to make sure they are round, smooth, and free from wear or damage.

7. Examine the hubs and bearing shoulders of the differential case where the side bearings will be mounted to make sure they are smooth and free of nicks, burrs, and other damage or wear.

8. If the side bearings are adjusted by adjusting nuts, make sure the threads on the hubs where the side bearings will be mounted are clean and undamaged.

9. Check the differential pinion shaft to make sure it is smooth and free from wear.

10. Examine the gear teeth and thrust surfaces for wear, uneven wear on gear teeth, and damage such as cracks, nicks, burrs, scoring, or pitting.

    NOTE: Gears that are damaged or worn in any way *must* be replaced. Chipped gears are a sign that there may be foreign material in the axle housing. Be particularly careful to clean the inside of the axle housing thoroughly before reinstalling the differential case in the housing. (Job Sheet 7)

11. Place the differential side gears in their appropriate bore in the axle housing and rotate them to make sure they move freely.

12. Inspect thrust washers for damage and wear.

13. Use a crocus cloth to smooth any nicks or burrs on the differential case or assembly parts.

14. Replace damaged or worn parts.

    NOTE: Manufacturers recommend that differential pinion gears and side gears be replaced as a set.

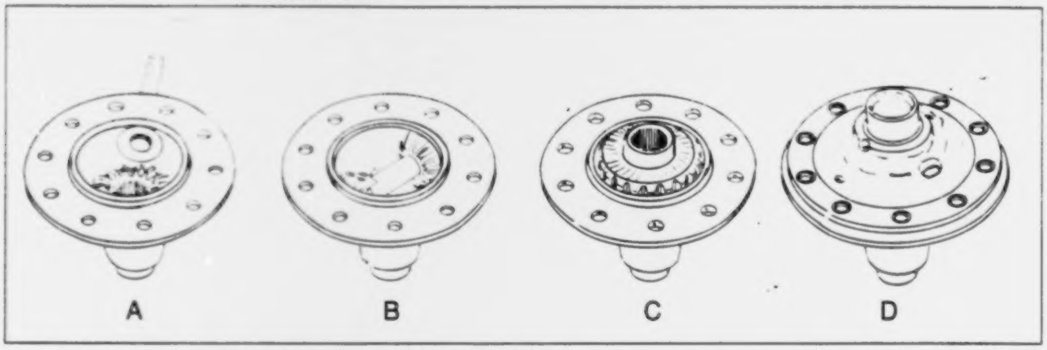
PROCEDURE **Adjust and replace the parts in a separable differential case assembly**

CAUTION

Check matchmarks to make sure all differential side gears, pinion gears, and washers are replaced in their original positions.

1. If the check for side gear to pinion gear backlash made before disassembly was excessive, replace all the thrust washers.
2. Place the side gear thrust washers on the side gear hubs.
3. Insert one differential side gear and its thrust washer into place inside the differential case. (Figure 3A)

FIGURE 3



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4. Install the pinion gear thrust washers on the pinion gears.
5. Place one of the pinion gears and its thrust washer inside the differential case on the end of the differential case nearest the pinion shaft lock bolt.
6. If one end of the differential pinion shaft is slotted, insert that end in the end of the pinion shaft hole where the pinion shaft lock bolt is located. (Figure 3A)
7. Align the hole in the pinion shaft, so that when it is completely inserted it will line up with the hole for the pinion shaft lock bolt.
8. If necessary, use a soft-faced mallet to drive the differential pinion shaft in just far enough to hold the differential pinion gear and its thrust washer.
9. Place the other pinion gear and its thrust washer inside the differential case.

10. Drive the pinion shaft all the way through the case. (Figure 3B)

11. Install the other side gear and its thrust washer. (Figure 3C)

12. Place the cover over the case, lining up the hole for the differential pinion shaft lock bolt. (Figure 3D)

13. Carefully insert the differential pinion shaft lock bolt and tighten it firmly.

    NOTE: The bolt will be torqued to specification after the differential case is reinstalled in the axle housing and the axles reinstalled.

14. Place the differential case securely in a bench vise.

15. Mesh the splined end of an axle shaft with a side gear.

16. Use the axle shaft to rock the differential side gears back and forth against the pinion gears.

17. If there is still more than the slightest play between the gears, the side gear to pinion gear backlash needs more adjustment.

18. Disassemble the differential assembly and replace the pinion gears and side gears.

19. If a final backlash check is not acceptable, replace the differential case.

20. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Adjust and replace the parts in a nonseparable differential case assembly

NOTE: If the original parts are being used, align matchmarks to make sure all differential side gears, pinion gears, and washers are replaced in their original positions.

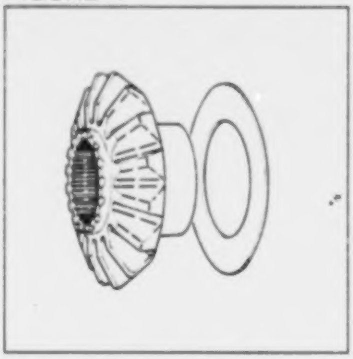
1. If the check for side gear to pinion gear backlash made before disassembly was excessive, replace all the thrust washers.

2. Place the side gear thrust washers on the side gear hubs and position both the differential side gears and their thrust washers in the differential case. (Figure 4)

3. Place the pinion gear thrust washers on the pinion gears.

4. Put one of the differential pinion gears in the opening between the two side gears.

FIGURE 4



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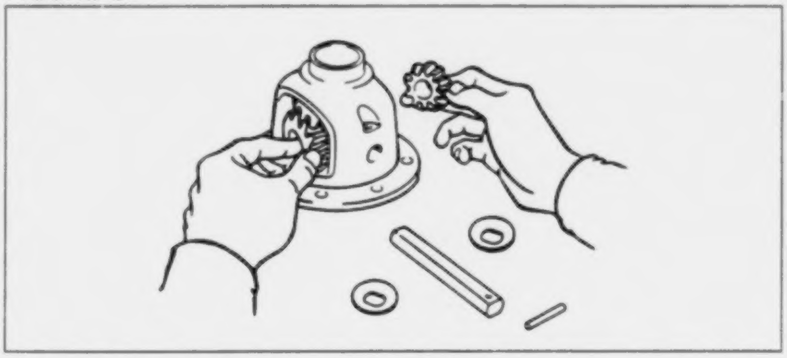
NOTE: Some pinion gear thrust washers are installed after the pinion gears are in place. Check your service manual.

5. Insert the other pinion gear and its thrust washer directly opposite it between the two side gears. (Figure 5)

FIGURE 5



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6. Turn both side gears until both pinion gears are inside the case and lined up with the pinion shaft hole.

7. If one end of the differential pinion shaft is slotted, insert that end in the end of the pinion shaft hole where the pinion shaft lock bolt is located.

8. Align the hole in the pinion shaft, so that when it is completely inserted it will line up with the hole for the pinion shaft lock bolt.

9. Use a soft-faced mallet to gently drive the differential pinion shaft through the differential case, holding both pinion gears in place.

10. Carefully insert the differential pinion shaft lock bolt and tighten firmly.

    NOTE: The bolt will be torqued to specification after the differential case is reinstalled in the axle housing and the axles reinstalled.

11. Place the differential case securely in a bench vise.

12. Mesh the splined end of an axle shaft with a side gear.

13. Use the axle shaft to rock the differential side gears back and forth against the pinion gears.

14. If there is still more than the slightest play between the gears, the side gear to pinion gear backlash needs more adjustment.

15. Disassemble the differential assembly and replace the pinion gears.

16. Reassemble the differential assembly and retest the side gear to pinion gear backlash.

17. If the backlash is still too great, replace the side gears as well.

18. If a final backlash check is not acceptable, replace the differential case.

19. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 12

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13L

Remove, inspect, measure, adjust, and replace limited-slip differential components.

INTRODUCTION

Because there are many different types of limited-slip differentials, there are many different methods of removing, adjusting, and replacing them. The appropriate service manual is extremely important in determining the correct procedures for working on any limited-slip differential. The procedures given here are general procedures for the two basic types of limited-slip differentials—the clutch type and the cone type.

EQUIPMENT AND MATERIALS

- Limited-slip differential case with assembly parts still installed
- Appropriate service manual
- Eye protection
- Large bench vise
- Vise
- Permanent marker or sharp awl
- Combination wrenches
- Soft-faced mallet
- Approved cleaning solvent
- Bristle brush
- Crocus cloth
- Low pressure air nozzle
- Shop towels

For clutch plate type differentials, you will also need:

- Brass drift
- Hammer
- 2 to 4 ¼ in. (6 mm.) bolts with nuts
- C-clamp
- Pinion gear rotator
- Socket wrench extension
- Outside micrometer
- Replacement shims and/or spacers
- Approved limited-slip lubricant
- Two small steel bars of bar stock no longer than the differential preload plate

For cone type differentials, you will also need:

- Torque wrench
- Arbor press
- Axle shaft that is used with the differential

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case should be removed from the axle housing. (Job Sheet 7) If necessary, the ring gear (Job Sheet 8) and the differential side bearings (Job Sheet 10) should be removed from the differential case.

PROCEDURE

Remove components from a clutch plate type limited-slip differential

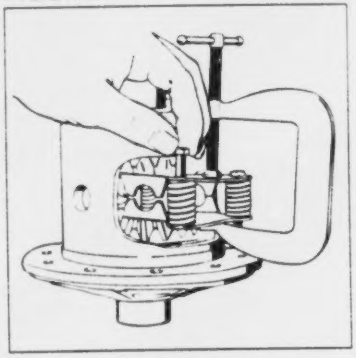
1. Place the differential securely in a large vise or differential holder.
2. Mark all the parts so they can be replaced in their original positions.
3. Remove the pinion shaft lock bolt with an appropriate wrench.
4. Tap out the differential pinion shaft using a brass drift and hammer.
5. Use the brass drift and hammer to drive the preload plates and spring pack out of the differential case just far enough to attach a C-clamp.

◆ WARNING ◆

Be extremely careful when working with the spring assembly in a clutch pack type differential. If the springs should slip loose, serious injury could result.

6. Wipe the preload plate with a clean shop towel to remove any lubricant.
7. Install ¼ in. (6 mm.) bolts through the preload plate and tighten them just enough to hold the spring assembly. (Figure 1)

FIGURE 1



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8. Remove the spring assembly from the differential case and tighten it in a vise.
9. Tighten the vise enough to loosen the preload plates so you can remove the bolts and C-clamp.
10. Remove the bolts.

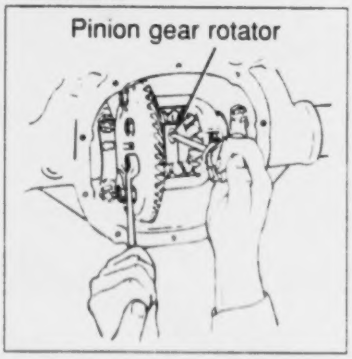
11. Loosen the vise slowly, removing the tension from the springs so you can disassemble the preload plates and spring assembly. Keep the parts together.

12. Place a pinion gear rotator between the pinion gears. (Figure 2)

13. Hold the ring gear with a box wrench. (Figure 2)

14. Place a socket wrench extension into the hole in the pinion gear rotator and slowly rotate the pinion gear until it and its thrust washer can be removed.

FIGURE 2



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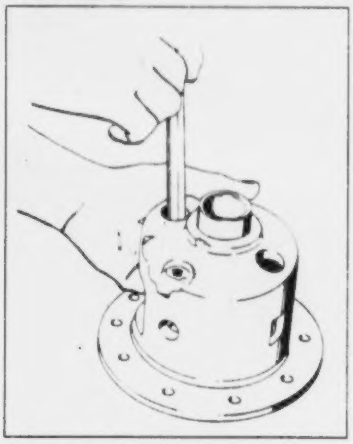
15. Remove the side gears, clutch disc guides, and clutch plates and discs as a single assembly by tapping them out with a hammer and brass drift. (Figure 3)

16. Separate the clutch pack assembly from the side gear.

17. Use an outside micrometer to measure the depth of the shims and/or spacers used with the clutch pack.

18. Discard the old shims and/or spacers and replace with replacement parts of the same depth.

FIGURE 3



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PROCEDURE

Remove components from a cone type limited-slip differential

1. Mark all the parts so they can be replaced in their original position.

2. Place the differential in a large vise or arbor press and clamp the jaws of the vise over the hubs where the differential side bearings are installed.

3. Tighten the vise slightly to overcome the preload of the springs.

4. Loosen, but do not remove, the bolts that hold the two halves of the differential case together.

5. Loosen the vise slightly.

6. Use a soft-faced mallet to tap on the half of the differential case containing the ring gear until the two case halves spring loose.

7. Remove the differential case from the vise and place it on a workbench with the ring gear half of the case on top.

8. Remove the differential case bolts and the ring gear half of the case.

9. Remove the remaining parts of the differential assembly from the case.

PROCEDURE

Inspect the parts of a limited-slip differential

1. Use the procedures outlined in Job Sheet 11 to clean and inspect the differential case, the pinion gears, side gears, thrust washers, pinion shaft lock bolt, and pinion shaft.

2. Use an approved cleaning solvent and bristle brush to clean the preload plates and springs and check them for damage or wear.

3. Do **not** use solvent to clean clutch discs and plates or cone assemblies—wipe them clean with a shop towel.

4. Inspect preload plates, clutch disc guides, and clutch plates and discs for worn, cracked, or distorted parts.

5. Slight grooves or scratches on a clutch cone or cone seat in the differential case are acceptable, but not if the wear or damage is deep.

   NOTE: If the cone and side gears or the case of a cone type limited-slip differential are worn or damaged, the entire assembly must be replaced.

6. Use a crocus cloth to remove any nicks or burrs.

7. Replace worn or damaged parts.

PROCEDURE

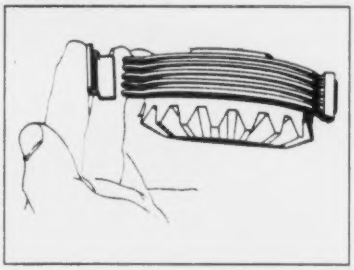
Replace and adjust components in a clutch plate type limited-slip differential

NOTE: Check matchmarks to make sure all differential assembly components are replaced in their original positions.

1. Use an approved limited-slip lubricant to lubricate all differential parts except the preload plates.
2. Soak clutch discs and plates in limited-slip lubricant for 30 minutes before assembly to assure a proper check for clutch pack preload.
3. Assemble the clutch pack—side gear, clutch discs and plates, and new shims and/or spacers—for the ring gear side of the differential.

   NOTE: One clutch plate disc has steel on one side and friction material on the other. Place this disc with its fiber side against the side gear hub. Alternate the rest of the discs following a friction disc with a steel disc.
4. Measure the clutch pack preload, referring to the service manual to determine the correct method for the vehicle.
5. Align the clutch disc and plate ears, position the clutch disc guide, and install the assembly in the differential. (Figure 4)
6. Install the other clutch pack in the same way.
7. Put the thrust washers on the pinion gears and position the two pinion gears on the side gears, exactly opposite each other.

FIGURE 4



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8. Place the pinion gear rotator between the pinion gears.
9. Hold the ring gear steady with a box wrench and use the socket wrench extension to rotate the pinion gears until they are lined up with the pinion shaft hole.

10. Assemble the preload plates and springs and place a small steel bar on the outside of both preload plates, leaving the bolt holes on the plates exposed.

11. Clamp the bar stock, preload plates, and springs in a vise.

CAUTION

Be extremely careful when working with the spring assembly in a clutch pack type differential. If the springs should slip loose, serious injury could result.

12. Tighten the vise, compressing the springs, and attach a C-clamp to the assembly.

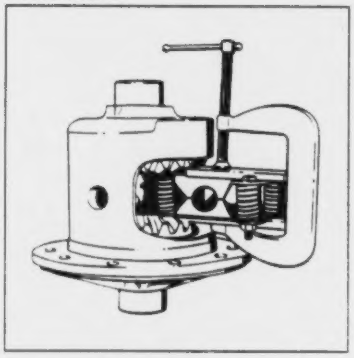
13. Remove the assembly from the vise and install ¼ in. (6 mm.) bolts through the springs and preload plates to hold the assembly under tension.

14. Align the preload plate with the gears and the hole for the differential pinion shaft.

15. Use a soft-faced mallet to drive the spring pack (with the C-clamp and bar stock still attached) part way into the differential case. (Figure 5)

16. Remove the ¼ in. bolts.

FIGURE 5



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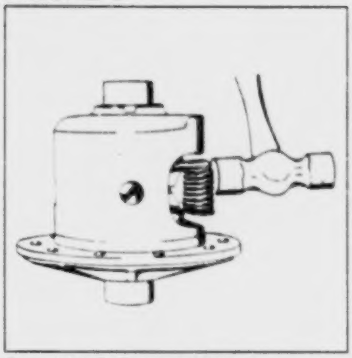
17. Remove the C-clamp and bar stock and drive the spring pack the rest of the way into the differential case. (Figure 6)

18. If one end of the differential pinion shaft is slotted, insert that end in the end of the pinion shaft hole where the pinion shaft lock bolt is located.

19. Align the hole in the pinion shaft, so that when it is completely inserted it will line up with the hole for the pinion shaft lock bolt.

FIGURE 6



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20. Use a soft-faced mallet to gently drive the differential pinion shaft through the differential case, holding both pinion gears in place.

21. Carefully insert the differential pinion shaft lock bolt and tighten firmly.

    NOTE: The bolt will be torqued to specification after the differential case is reinstalled in the axle housing, and the axles reinstalled.

22. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Replace the components in a cone type limited-slip differential

NOTE: Check matchmarks to make sure all differential assembly components are replaced in their original positions.

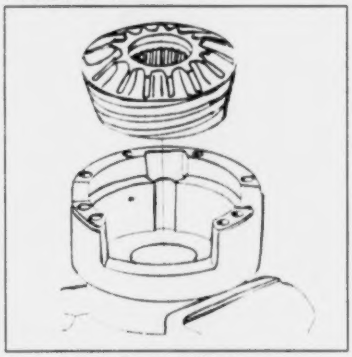
1. Use an approved limited-slip lubricant to lubricate all differential parts, except the thrust plates and case bolts and any surfaces that come in contact with these bolts.

    NOTE: If the case bolts are lubricated, their torque reading will be incorrect.

2. Place the half of the differential case without the ring gear in a vise with the open side up to provide access to the inside of the case.

3. Place the correct cone and side gear inside the case, seating it in position. (Figure 7)

FIGURE 7



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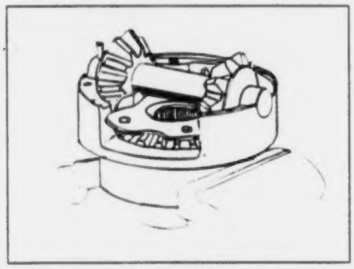
4. Assemble the thrust plate, pinion shaft, springs, and pinion gears and thrust washers in position. (Figure 8)

FIGURE 8



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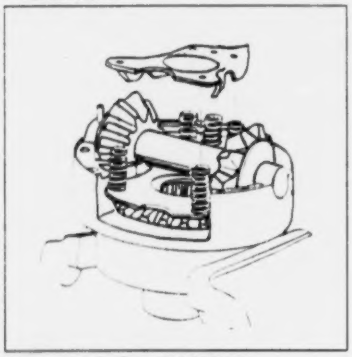
5. Position the springs and the other thrust plate on top of the pinion shaft. (Figure 9)

FIGURE 9



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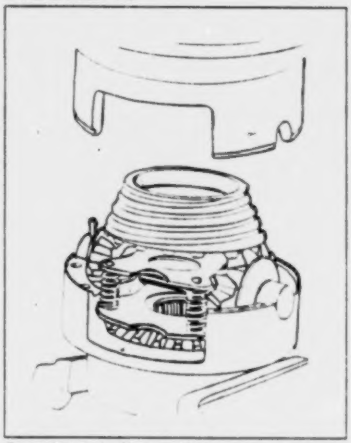
6. Place the other cone on top of the thrust plate and put the other half of the case (containing the ring gear) on top, seating it in position. (Figure 10)

7. Carefully insert the differential pinion shaft lock bolt and tighten firmly.

   NOTE: The bolt will be torqued to specification after the differential case is reinstalled in the axle housing, and the axles reinstalled.

FIGURE 10



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8. Remove the differential case from the vise and place it in a large vise or arbor press with the jaws of the vise over the hubs where the differential side bearings are installed.

9. Tighten the vise slightly to overcome the preload of the springs.

10. Install two case bolts on opposite sides of the differential case, tightening them with your hands.

    NOTE: Make sure all oil is wiped from the case bolts and bolt holes, or you will get a false torque reading when the bolts are torqued.

11. Install the remaining case bolts with your hands.

12. Remove the differential case from the vise or press.

13. Torque the bolts to specifications.

14. Secure the axle shaft that mates with the differential in a soft-jawed bench vise, splined end up.

15. Place the differential case on the axle shaft, mating the shaft with the side gear inside the case.

16. Use a torque wrench to determine the amount of torque necessary to rotate one side gear while the other side gear is being held immovable.

    NOTE: The correct torque reading is the one necessary to *keep* the side gear rotating, not the one necessary to *begin* the side gear rotating.

17. Compare the torque reading to manufacturer's specifications.

18. If the torque is not within specifications, make needed adjustments.

19. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

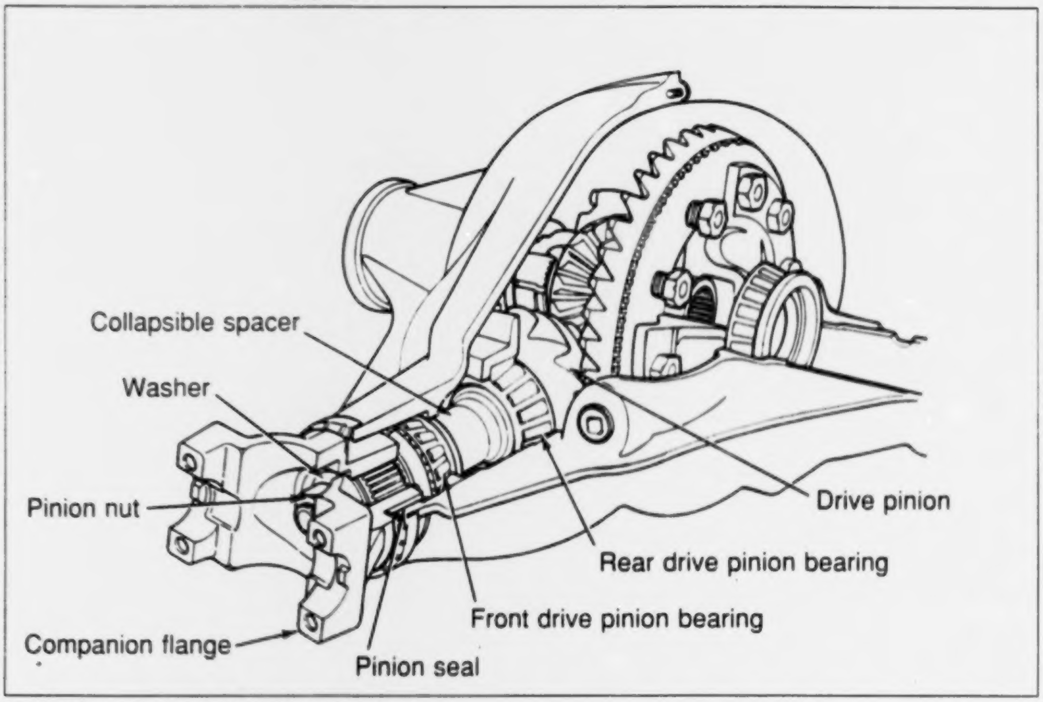
JOB SHEET 13

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

OBJECTIVE 13M

Remove and inspect a drive pinion gear assembly.

FIGURE 1


Collapsible spacer
Washer
Pinion nut
Companion flange
Pinion seal
Front drive pinion bearing
Rear drive pinion bearing
Drive pinion

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INTRODUCTION

The drive pinion gear assembly must be removed if the Drivetrain and Axles Specialist observes or suspects damage in the drive pinion assembly, if the drive pinion bearing preload is insufficient, or if the ring gear tooth contact pattern check revealed a need for a drive pinion gear depth adjustment.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 5, ***Cleaning, Inspecting, and Lubricating Antifriction Bearings***
- Supplement 6, ***Tapered Roller Bearing Damage Diagnosis Chart***
- Supplement 7, ***Removing and Replacing Pressed-on Bearings***
- Eye protection
- Combination wrenches
- Shop towels

- Bearing puller or a hammer and brass punch
- Soft-faced mallet
- Arbor press
- Rear pinion bearing cone remover or a bearing puller
- Outside micrometer
- Pencil and paper
- Stiff brush
- Bristle brush
- Approved cleaning solvent
- Low-pressure air nozzle
- Crocus cloth

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported, and the rear axle lubricant drained. (Job Sheet 1) The rear wheels, brake drums, rear axle shafts (Job Sheet 2), and driveline (Unit 1, Job Sheet 3) should be removed. The differential case should be removed from the removable carrier or differential housing (Job Sheet 7), and if the vehicle has an integral carrier, the companion flange and pinion seal should be removed (Job Sheet 6).

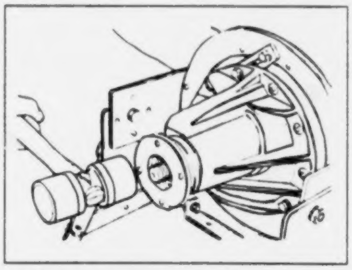
PROCEDURE

Remove the parts of the drive pinion gear assembly

1. Reverse the pinion nut on the drive pinion shaft and rethread it back onto the shaft to protect the shaft threads.
2. Place one or two shop towels in the bottom of the differential housing to keep the drive pinion assembly from being damaged when it is driven out.
3. If the assembly is contained in an integral housing, replace the rear housing cover and secure it with two rear cover bolts to keep the drive pinion assembly from falling onto the floor when it is driven out.
4. Tap the drive pinion shaft gently but squarely with a soft-faced mallet to drive the drive pinion gear from the differential housing. (Figure 2)

   NOTE: Some manufacturers recommend using special pinion removal tools.

FIGURE 2



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5. Remove the rear housing cover.

6. Remove the drive pinion gear from the housing and discard the collapsible spacer.

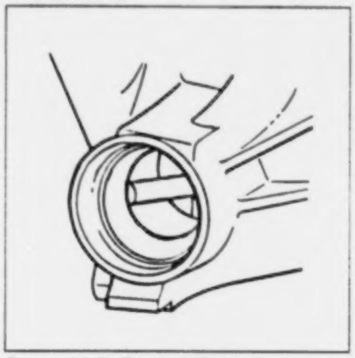
   NOTE: The rear drive pinion bearing is pressed on the shaft of the drive pinion gear and will come out with the gear.

7. Remove the front bearing cone from the axle housing.

8. Remove the outer race of the front pinion bearing from the differential housing using a bearing puller or a brass punch and a hammer to tap firmly on alternating sides of the race, forcing it out the front of the housing. (Figure 3)

   NOTE: Some differential housings have slots along the sides of the housing bore to help align the drift for this task.

FIGURE 3



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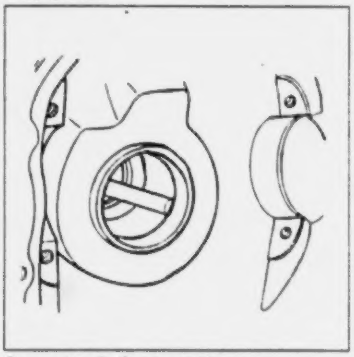
9. Use the same method to remove the outer race of the rear pinion bearing, forcing it out the rear of the housing. (Figure 4)

FIGURE 4



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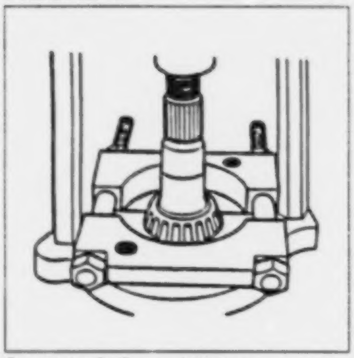
10. Use an arbor press with a rear pinion bearing cone remover or a bearing puller to remove the rear drive pinion bearing from the shaft of the drive pinion gear—see Supplement 7, "Removing and Replacing Pressed-on Bearings," for the correct procedure. (Figure 5)

FIGURE 5



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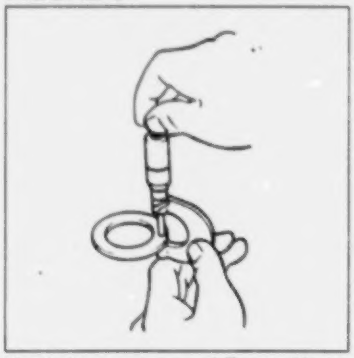
11. Remove the rear depth shim and use an outside micrometer to measure its thickness. (Figure 6)

FIGURE 6



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12. Record the measurement.

PROCEDURE

Inspect drive pinion gear assembly

1. Use a stiff brush and approved cleaning solvent to clean the area of the differential housing where the drive pinion gear assembly was installed.
2. Use an approved cleaning solvent and bristle brush to clean the drive pinion gear and companion flange.
3. Air dry or blow dry the parts with a low-pressure air nozzle.
4. After drying, apply a thin coat of rear axle lubricant to all parts.

5. Clean and inspect the bearings using the procedures in Supplement 5, "Cleaning, Inspecting, and Lubricating Antifriction Bearings," and Supplement 6, "Tapered Roller Bearing Damage Diagnosis Chart."

6. Inspect the differential housing where the drive pinion assembly is installed for cracks, scoring, nicks, rough tool marks, burrs, or other damage or wear.

   NOTE: Give special attention to the bore where the oil seal and pinion bearings are installed—make sure there is nothing that would damage the seal or cause the bearings not to seat properly.

7. Examine the drive pinion gear teeth for wear and damage.

   NOTE: Chipped gears are a sign that there may be foreign material in the axle housing. Be particularly careful to clean the inside of the axle housing thoroughly before reinstalling the differential case in the housing.

8. Examine the drive pinion shaft and the companion flange for damage or wear.

9. Use a crocus cloth to smooth any nicks or burrs on the differential housing and parts of the drive pinion assembly.

10. Replace parts that are even slightly damaged or worn.

11. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

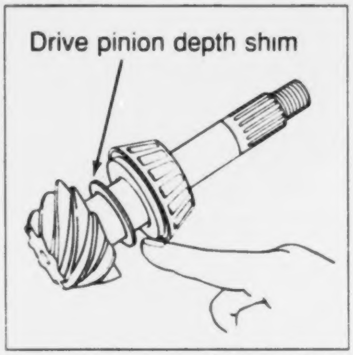
SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

OBJECTIVE 13N **Measure and adjust drive pinion depth.**

INTRODUCTION

The accuracy with which the ring gear and the drive pinion gear mesh is critical to the proper functioning of the differential. To achieve an accurate mesh between these two gears, the drive pinion must be set at the correct depth to meet the ring gear. This adjustment, the ***pinion depth setting***, is controlled by the ***drive pinion depth shim*** which is located either between the head of the drive pinion gear and the rear pinion bearing (Figure 1) or between the rear pinion bearing and a shoulder in the housing bore.

FIGURE 1



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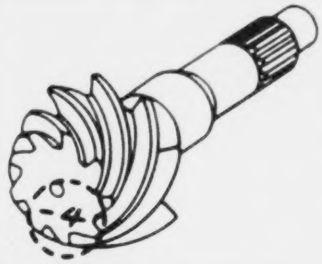
If the ring gear tooth contact pattern was satisfactory and if you are reusing the original ring and pinion gear set and rear drive pinion bearing, the width of the depth shim is usually the same, and it will not be necessary to measure or adjust the drive pinion depth. However, even when these parts are reused, a new shim—the same width as the old one—is always installed.

Drive pinion depth **must** be measured and adjusted if:

- You are installing a new ring and pinion gear set, rear drive pinion bearing, or axle housing.
- The ring gear tooth contact pattern shows that the drive pinion depth setting needs to be adjusted.



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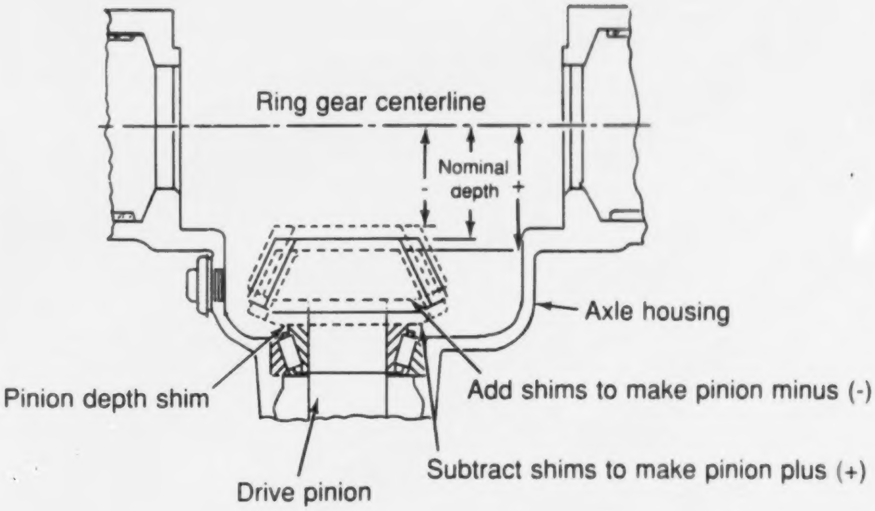
READING A DRIVE PINION GEAR DEPTH MARKING

Some drive pinion gears are marked on their face or side with a positive or negative number called a ***pinion marking***. This number tells how much shim width must be added or removed to set that individual drive pinion gear to the best depth setting for operation with its ring gear.



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Individual ring and pinion gear sets are tested at the factory to determine the depth setting for the set that yields the quietest operation and best tooth contact pattern. When the best setting is determined, that distance is compared to the manufacturer's standard depth setting (called the "nominal" depth). A negative (-) number means the best distance for this individual drive pinion gear is *closer* to the ring gear than the standard setting. A positive (+) number means the best operating distance for this drive pinion gear is *farther* from the ring gear. Each number equals .001 of an inch in distance. **EXAMPLE:** A drive pinion marked "-3" needs shims equalling .003 in. *added* to the standard depth to achieve its best operating depth. A pinion marked "+1" needs to have .001 in. *subtracted* from the standard depth to operate best.

Knowing how to read a drive pinion gear depth marking is not very important if the drive pinion depth is satisfactory—simply use the same size shim. But it is very important if the depth setting must be changed.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, Unit 1, ***Using a Dial Indicator***
- Eye protection
- Rear axle lubricant
- Drive pinion bearing installation tool
- Hammer
- Drive pinion depth gauge recommended by the vehicle's manufacturer
- Combination wrenches
- Socket wrench
- Sockets and adapters
- Torque wrench
- Dial indicator
- Manufacturer-recommended replacement shims and spacers

NOTE: You will need a variety of sizes of shims to choose from in order to make the correct adjustment.

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case assembly (Job Sheet 7) and the drive pinion gear assembly (Job Sheet 13) should be removed from the axle housing. The parts of the drive pinion assembly should be cleaned, inspected, and replaced if worn or damaged (Job Sheet 13).

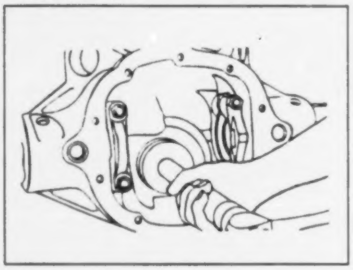
PROCEDURE

Measure drive pinion depth

1. If the rear pinion bearing is being replaced, use a drive pinion bearing installation tool to install a new bearing race. (Figure 2)

   NOTE: Remember to lubricate the housing bore and the outside of the bearing race before positioning the bearing installation tool. See Job Sheet 18 for a more complete description of this procedure.

FIGURE 2



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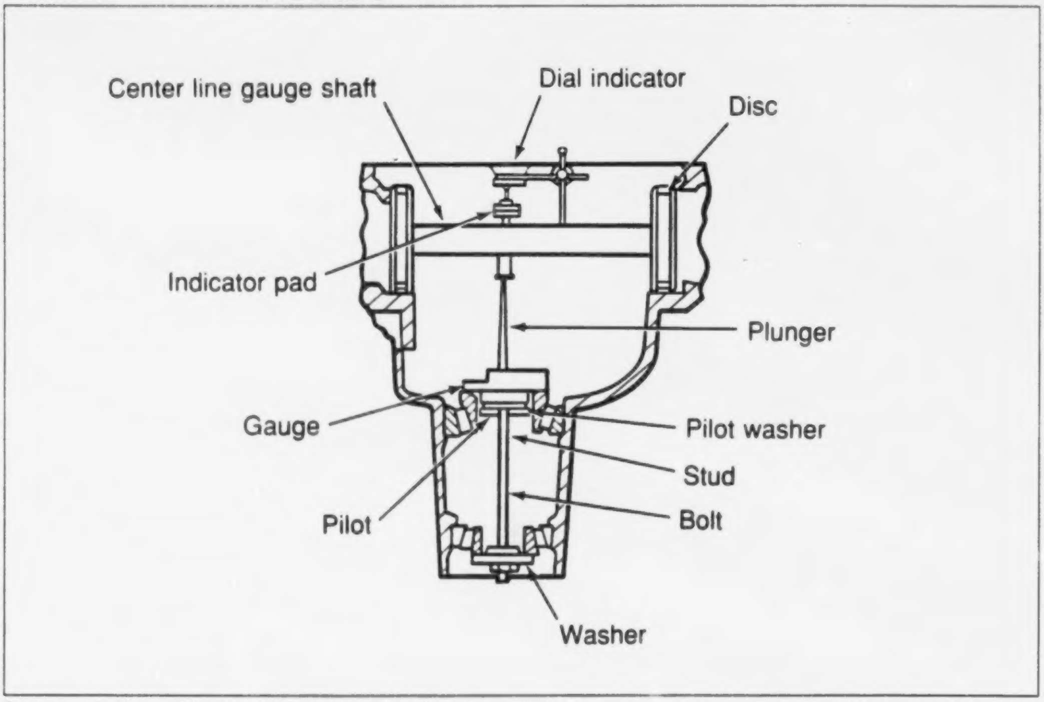
2. If the front pinion bearing is to be replaced, use a drive pinion bearing installation tool to install the outer race of this bearing.

3. Install the lubricated front and rear bearing cones in the bearing races.

4. Install the gauge plate assembly in the bore between the front and rear bearings. (Figure 3)

FIGURE 3


Center line gauge shaft
Dial indicator
Disc
Indicator pad
Plunger
Gauge
Pilot washer
Stud
Pilot
Bolt
Washer

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5. Use a socket wrench with an adapter to hold the gauge plate stationary on the inside of the differential housing.

6. Tighten the nut on the outside of the gauge assembly.

7. Rotate the gauge assembly several times to seat the bearings.

8. Still holding the gauge plate stationary, use a torque wrench to tighten the nut on the outside to specification.

9. Install the bearing discs, gauge shaft, and other indicator parts in the differential housing according to instructions.

10. Install the bearing caps and torque the cap bolts to specifications.

11. Position the dial indicator squarely on the gauge block.

12. Preload the dial indicator and tighten the bezel clamp screw.

13. Set the dial indicator to zero.

14. Rotate the gauge shaft back and forth until the dial indicator shows the highest positive reading.

15. Zero the indicator again.

16. Rock the gauge shaft back and forth again to verify the zero setting.

17. Rotate the gauge shaft until the depth gauge plunger does not touch the gauge block.

18. Read the dial indicator—the reading equals the shim thickness required to position the drive pinion gear at the correct nominal depth.

19. Check the pinion marking on the drive pinion gear that will be installed and multiply that number times .001 in.

20. If there is no pinion marking number or if there is a "0" on the drive pinion gear, use the shim thickness from the dial indicator reading to set the drive pinion depth correctly.

21. If the number has a "-," **add** that width to the thickness of the shim(s) needed to reach the nominal depth.

22. If the number has a "+," **subtract** that width to the thickness of the shim(s) needed to reach the nominal depth.

23. To adjust drive pinion depth, use a new shim(s) of the correct width when reinstalling the drive pinion gear assembly (Job Sheet 15).

24. Remove the bearing caps and drive pinion depth gauge.

25. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 15

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13O

Replace drive pinion gear assembly components and measure and adjust drive pinion bearing preload.

INTRODUCTION

The replacement of the drive pinion gear assembly is the procedure that begins the reassembly of the differential and rear axle. Because the procedure involves the placement of pressed-on bearings and oil seals that could be easily damaged if they had to be removed again, it is important to make sure that all procedures that may have been required are completed. Here is a checklist of procedures that should be completed before the drive pinion assembly is replaced:

- The axle housing should be cleaned. (Job Sheet 7)
- The parts of the drive pinion gear assembly should be cleaned, inspected, and worn or damaged parts replaced. (Job Sheet 13)
- If necessary, drive pinion depth should be measured, and a new pinion depth control shim of the proper width selected. (Job Sheet 14)

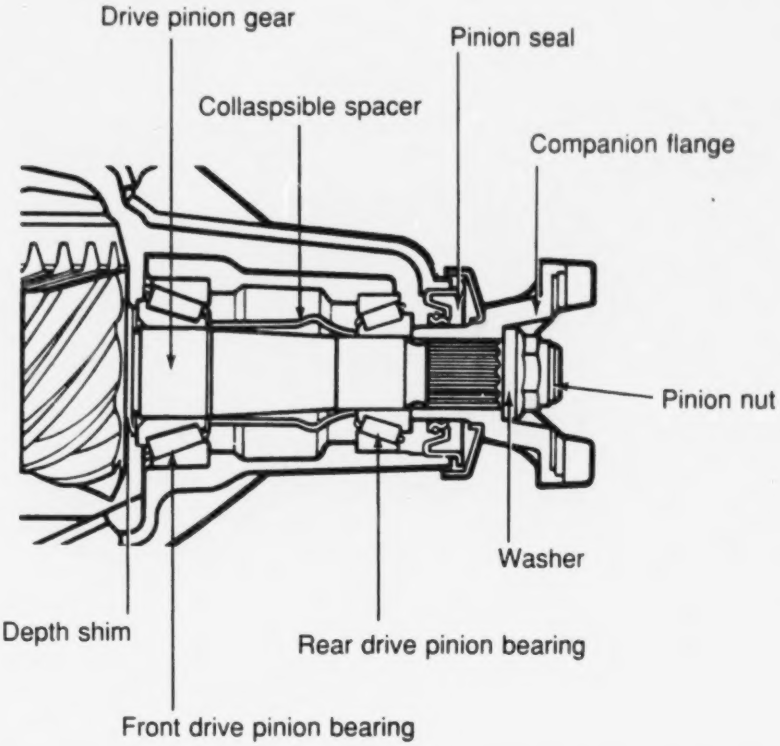
  NOTE: The front and rear drive pinion bearing races should have been installed as part of the procedure for measuring the drive pinion depth. (Job Sheet 14)

- If the vehicle's service manual recommends that the differential side bearing preload be adjusted before the drive pinion assembly is reinstalled, the side bearing preload should have been adjusted. (Job Sheet 5)

After the drive pinion gear assembly is reinstalled, it is important that the position of the drive pinion gear be held absolutely constant in its relationship to the ring gear. If the drive pinion gear assembly moves forward or back even slightly, the operation of the differential will be impaired.

To insure that the drive pinion assembly does not move, a collapsible spacer is installed between the front and rear pinion bearings. When the drive pinion assembly is reinstalled, the pinion nut is slowly torqued to specification, and this spacer collapses—exerting a preload pressure on the drive pinion bearings. This preload pressure keeps the drive pinion assembly from moving. (Figure 1)

FIGURE 1


Drive pinion gear
Pinion seal
Collaspsible spacer
Companion flange
Pinion nut
Washer
Depth shim
Rear drive pinion bearing
Front drive pinion bearing

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EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 7, ***Removing and Replacing Pressed-on Bearings***
- Eye protection
- Parts of the drive pinion assembly
- Replacement drive pinion depth control shim
- Replacement collapsible spacer for the drive pinion gear
- Replacement pinion nut washer
- Replacement pinion nut
- Arbor press
- Bearing installation tool
- Masking tape
- Rear axle lubricant
- Drive pinion seal installation tool
- Hammer
- Companion flange holding tool
- Socket and ratchet
- Beam-type lb.-in. torque wrench

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case assembly (Job Sheet 7) and the drive pinion gear assembly (Job Sheet 13) should be out of the axle housing.

PROCEDURE

Replace drive pinion gear assembly components

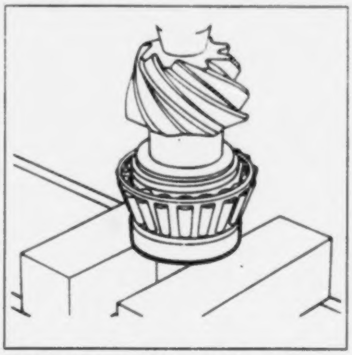
1. Place the new drive pinion depth control shim on the drive pinion gear.

   NOTE: Do **NOT** use the old shim—even if it is the right width.

2. Refer to Supplement 7, "Removing and Replacing Pressed-on Bearings," and use an arbor press and a bearing installation tool to press the rear bearing cone on the drive pinion shaft, pressing it firmly against the head of the drive pinion gear. (Figure 2)

3. Make sure both drive pinion bearing cones are properly lubricated with rear axle lubricant.

FIGURE 2



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4. Place the front bearing cone in its race in the housing.

5. Install a new collapsible spacer behind the rear bearing cone on the drive pinion gear shaft.

   NOTE: The end of the spacer with the larger diameter should face the drive pinion gear head.

6. Wrap the splines and threads on the drive pinion gear stem in masking tape to insure they do not damage the pinion seal when it is installed.

7. Insert the drive pinion gear from the rear of the housing through the front pinion bearing.

8. Check the replacement pinion seal to make sure it conforms to manufacturer specifications.

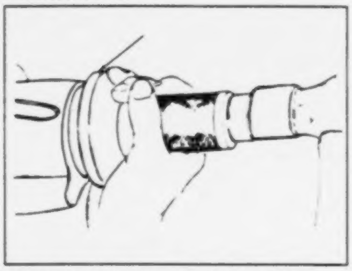
9. Place a thin coat of rear axle lubricant on the inside of the housing bore and the outside edge and sealing lip of the replacement seal.

NOTE: Some oil seals are specially coated and need no lubricant—check your service manual for manufacturer's recommendation.

10. Use the proper seal installation tool to install the pinion seal, making sure it is positioned squarely, not cocked, in the housing bore. (Figure 3)

11. Remove the masking tape from the drive pinion gear splines and threads.

FIGURE 3



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12. Place a thin coat of rear axle lubricant on the splines and sealing surface of the new or replacement companion flange.

13. Place the companion flange on the drive pinion gear shaft and hold it firmly against the front pinion bearing.

14. Place a pinion nut and a new washer on the drive pinion gear shaft.

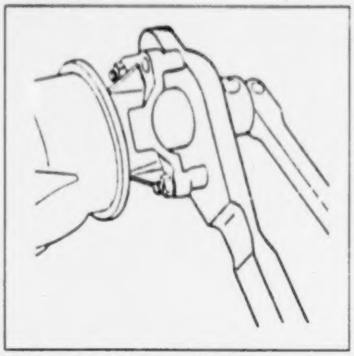
NOTE: Manufacturers recommend the use of a new pinion nut.

PROCEDURE

Measure and adjust drive pinion bearing preload

1. Hold the companion flange with the companion flange holding tool and use a socket and ratchet to tighten the pinion nut *a little at a time*. (Figure 4)

FIGURE 4



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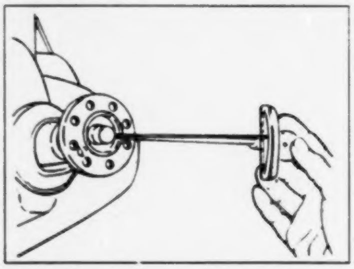
2. After each tightening, turn the drive pinion by hand several revolutions to set the roller bearings and then check the drive pinion bearing preload with a beam type lb.-in. torque wrench. (Figure 5)

   NOTE: The correct torque reading is the one which *keeps* the drive pinion rotating, not the reading which *starts* the drive pinion rotating.

FIGURE 5



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3. Torque the pinion nut to preload specifications.

4. When the correct preload torque specification is reached, rotate the companion flange by hand several revolutions.

5. Check the torque reading once more to make sure that rotating the bearings did not change the preload setting.

   NOTE: If you should accidentally torque the nut too high, remove the drive pinion assembly and replace the collapsible spacer. It is not possible to back off once the spacer has been collapsed too much.

6. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 16

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13P

Replace and adjust the differential case assembly.

INTRODUCTION

The differential case is replaced in the axle housing after the drive pinion assembly has been installed but before the rear axles are replaced. Because this is a procedure that continues the reassembly, the Manual Drivetrain and Axles Specialist will want to make sure that all required procedures have been completed prior to replacement. Here is a checklist of procedures that should be completed before the differential case assembly is replaced:

- The axle housing should be cleaned and inspected. (Job Sheet 7)
- The drive pinion gear assembly should be replaced. (Job Sheet 15)
- The differential case assembly components should be cleaned, inspected, and replaced in the differential case. (Job Sheet 11 or 12)
- The ring gear should be reinstalled. (Job Sheet 8)
- If the differential side bearing cones have been removed or replaced, reinstall them on the differential case. (Job Sheet 10)

If the vehicle has an integral carrier, the axle housing must remain open after the differential case is replaced so that the rear axles can be installed. However if there is a removable carrier axle housing, the carrier can be reinstalled on the housing after the differential case is replaced, since the axles on this type of housing are replaced with the axle housing closed.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Rear axle lubricant
- Combination wrenches
- Torque wrench

If the carrier on a removable carrier axle housing is to be replaced, you will also need:

- Hoist stand
- Replacement gasket for the axle housing
- Thread-locking compound

NOTE: You will need the help of an assistant to replace a removable carrier housing.

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The differential case assembly should be out of the axle housing. (Job Sheet 7) The drive pinion assembly should be replaced in the housing. (Job Sheet 15)

PROCEDURE

Install and adjust the differential case assembly

NOTE: Check matchmarks to make sure all differential assembly components are replaced in their original positions.

1. Put a light coat of rear axle lubricant on the differential side bearing cones, bearing races, and adjusting nuts (if present).
2. Place the differential side bearing races on the bearing cones.
3. Install the adjusting nuts (if present).
4. Place the differential case in the housing or carrier.
5. If the ring and pinion gears are a nonhunting gear set, position the marked tooth on the drive pinion gear between the two marked gear teeth on the ring gear.
6. Measure and adjust the side bearing preload. (Job Sheet 5)

   NOTE: Some manufacturers recommend that side bearing preload be adjusted before replacing the drive pinion assembly, so this procedure may already have been done.
7. Measure and adjust the ring to pinion gear backlash. (Job Sheet 5)
8. Make sure the side bearing caps have been correctly replaced and that their bolts have been torqued to specifications.
9. Recheck the ring gear tooth contact patterns to insure that all needed adjustments have been made. (Job Sheet 4)
10. Make additional adjustments if needed.
11. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Replace the carrier in a removable carrier housing

♦ WARNING ♦

The carrier section of a removable carrier axle housing is very heavy—use the help of an assistant to lift and support the carrier during reinstallation.

1. Install a replacement gasket on the axle housing.
2. Support the carrier on a hoist stand.
3. Position the carrier on the axle housing studs.
4. Apply thread-locking compound to the studs before tightening the housing bolts with your fingers.
5. Use a torque wrench to torque the bolts to specification using a star pattern.
6. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 17 — SERVICE DIFFERENTIALS AND REAR DRIVE AXLES — II

OBJECTIVE 13Q

Inspect and replace rear axle shaft wheel studs.

INTRODUCTION

Wheel studs (sometimes called lugs) on the rear axle shaft flange bolt the drive wheel to the drive axle. If the wheel studs are bent, loose, or damaged, or if the threads on the studs are damaged, the wheel studs will have to be replaced. Wheel studs can be replaced whether the axle is on or off the vehicle. If the axle is off the vehicle, an arbor press can be used to remove the old studs; if the axle is on the vehicle, use a portable press.

EQUIPMENT AND MATERIALS

- Rear axle shaft
- Appropriate service manual
- Eye protection
- Arbor press or portable press
- Lug wrench
- Hammer and punch, if needed
- Replacement wheel studs, washers, and nuts
- Extra washers

> **CAUTION**
> **Always** check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect and replace rear axle shaft wheel studs

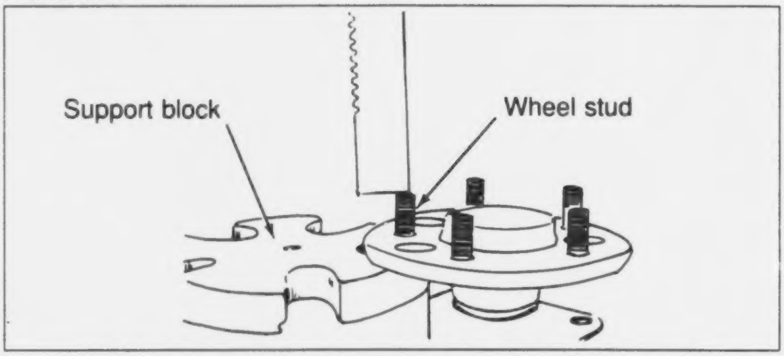
1. Examine the wheel studs to determine if they are bent, loose, or damaged.

2. Identify wheel studs that need replacement.

   NOTE: If one wheel stud is loose or damaged, replace all of the wheel studs. If the threads on a wheel stud are stripped, replace only the stripped wheel stud.

3. If the axle is off the vehicle, place the axle shaft flange—wheel studs up—in an arbor press, making sure the flange is properly supported. (Figure 1)

FIGURE 1



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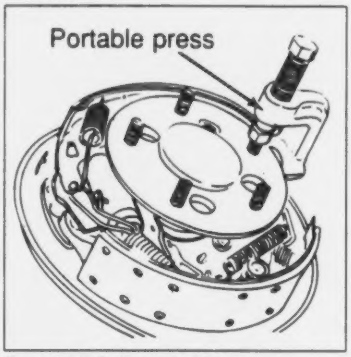
4. If the axle is on the vehicle, position a portable press on the wheel stud with the screw assembly toward the outside of the axle shaft flange. (Figure 2)

5. Press the wheel stud out the back of the axle shaft flange.

6. If the stud is broken, use a hammer and punch to remove the stud.

FIGURE 2



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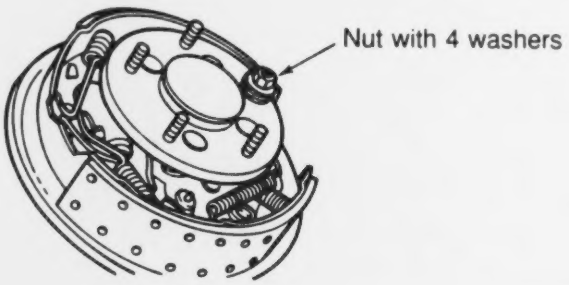
7. Place the new wheel stud in the flange hole and press into place by hand.

8. Place 3-4 washers on the wheel stud. (Figure 3)

FIGURE 3



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9. Screw the stud nut on the wheel stud with its flat side against the washers.

10. Tighten the stud nut with a lug wrench until the wheel stud is flush with the inside surface of axle shaft flange.

11. Remove the stud nut and washers.

12. Repeat the procedure for the other damaged wheel studs.

13. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 18

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13R

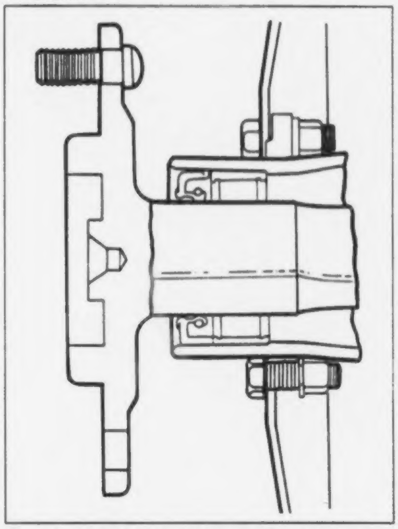
Remove, inspect, and replace rear axle shaft seals and bearings.

INTRODUCTION

On rear axles that have been secured by C-locks, the shaft seal and bearing will remain in the axle housing when the axle is removed. The procedures for removal and replacement of oil seals and bearings given here are most closely applicable for axles secured with C-locks.

On rear axles secured by retainer plates, the axle shaft oil seal, bearing, and inner and outer retainers will come out with the axle. To remove the seal, bearing, and retainers from such an axle, follow the procedure for removing axle shaft pressed-on bearings and retainers (Job Sheet 19).

FIGURE 1



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EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle with rear axles secured by C-locks
- Appropriate service manual
- Supplement 5, ***Cleaning, Inspecting, and Lubricating Antifriction Bearings***
- Supplement 6, ***Tapered Roller Bearing Damage Diagnosis Chart***
- Supplement 8, ***Straight Roller Bearing Damage Diagnosis Chart***
- Eye protection
- Steel ruler
- Pencil and paper
- Shop light or other bright light
- Magnifying glass
- Shop towels
- Crocus cloth
- Rear axle lubricant
- New rear axle oil seal
- Replacement bearings as required

- Slide hammer with axle shaft bearing remover attachment
- Axle bearing installation tool
- Axle seal installation tool
- Soft-faced mallet

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported and the rear axle removed from the vehicle. (Job Sheet 2)

PROCEDURE

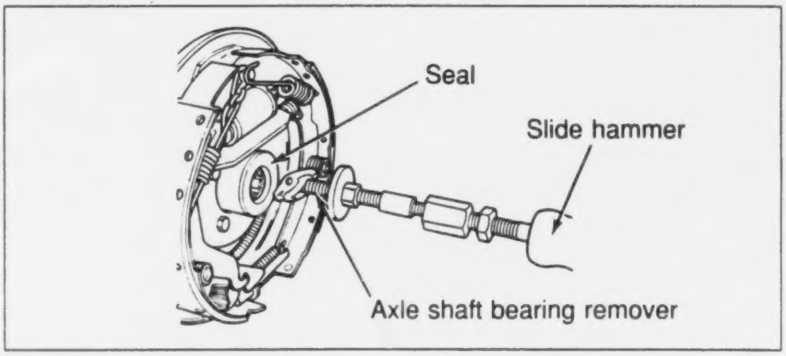
Remove rear axle shaft seals and bearings

1. Use a slide hammer with an axle shaft bearing remover attachment to remove the oil seal from the axle housing. (Figure 2)

   CAUTION

   Be sure not to damage the axle housing.

FIGURE 2



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2. Use a steel ruler to measure the distance from the edge of the axle housing to the bearing; record the measurement.

3. Use the slide hammer with axle shaft bearing remover attachment to remove the bearing from the axle housing.

4. Repeat the procedures for the other axle oil seal and bearing.

PROCEDURE

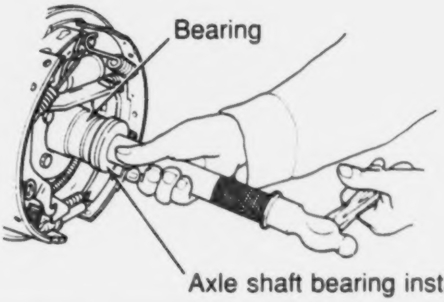
Inspect the rear axle bearings and replace the rear axle shaft seals and bearings

1. Use Supplement 5, "Cleaning, Inspecting, and Lubricating Antifriction Bearings," and Supplement 6 or 8, "Tapered (or Straight) Roller Bearing Damage Diagnosis Chart," to clean and inspect the rear axle bearings.
2. Wipe the axle housing bore clean with a shop towel.
3. Inspect the housing for rust, burrs, or rough spots.
4. Smooth imperfections with a crocus cloth.

   NOTE: Check rear axle shaft runout (Job Sheet 21) before replacing the rear axle shaft seals and bearings.

5. Check the replacement seals and bearings to make sure they meet the specifications in the service manual.
6. With a small amount of rear axle lubricant, coat the inside of the axle housing where the seal and bearing will be installed.
7. Make sure the bearing is properly lubricated.
8. Use the bearing installation tool to install the bearing squarely in the axle housing. (Figure 3)

FIGURE 3



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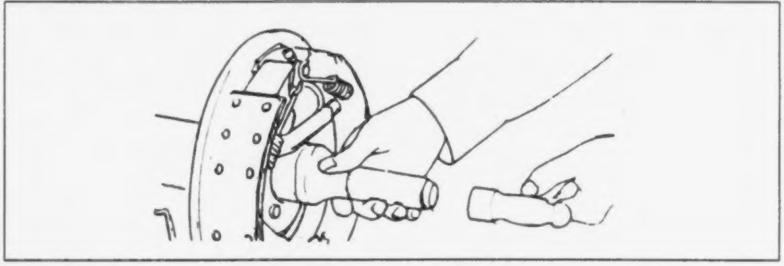
NOTE: Most axle housings have a shoulder inside which will stop the bearing at the correct position. If there is no shoulder, the bearing installation tool will set the bearing at the proper depth. If the correct bearing installation tool is not available, install the bearing in the axle housing the exact distance from the end of the axle housing measured for the original bearing.

CAUTION

The steel of the bearing is harder than the metal used in the axle housing. If the bearing is not absolutely square in the axle housing, it may shave off some of the metal in the axle housing as it is installed. Make sure the bearing is installed squarely and not cocked (set at an angle).

9. Lubricate the rubber part of the seal with rear axle lubricant as recommended in the vehicle service manual.
10. Place the seal on the axle seal installer with the inside face towards the differential.
11. Position the axle seal installer carefully at the axle housing opening and tap the seal gently and squarely into the housing with a soft-faced mallet. (Figure 4)

FIGURE 4



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12. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

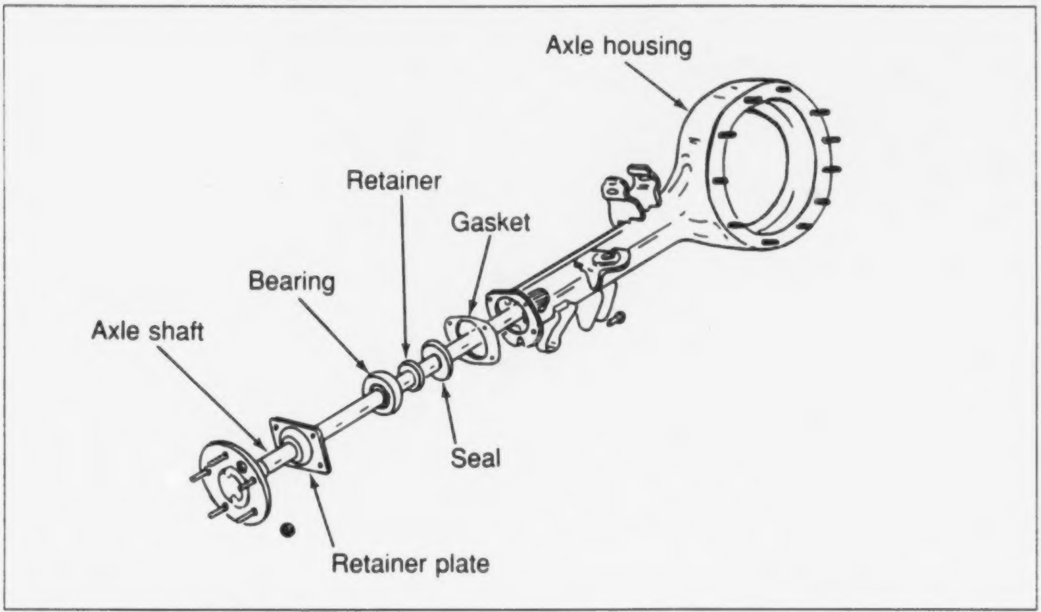
OBJECTIVE 13S

Remove and replace axle shaft pressed-on bearings and retainers.

INTRODUCTION

On rear axles secured by retainer plates, the axle shaft oil seal, inner bearing race, and outer retainer will usually come out with the axle when it is removed. (Figure 1) If the bearing is a tapered bearing, the outer bearing race may occasionally remain in the axle housing and can be removed easily using a slide hammer with a bearing removal attachment.

FIGURE 1



Used with permission of Chrysler Corporation.

The axle bearing and retainer are pressed on the axle shaft and will have to be removed with a bearing puller or an arbor press. There are several types of pullers that can be used to pull off a pressed-on bearing, but for this procedure, an arbor press will be used. Supplement 7, "Removing and Replacing Pressed-on Bearings," will give you additional useful information regarding the procedures in this job sheet. The bearing, retainers, and oil seal are arranged in a different order on different axle assemblies.

EQUIPMENT AND MATERIALS

- Rear axles which have been secured by retainer plates
- Appropriate service manual
- Supplement 7, ***Removing and Replacing Pressed-on Bearings***
- Eye protection
- Bench vise
- Chisel
- Hammer
- Arbor press
- Bearing remover/installer for arbor press
- Replacement bearing retainers
- Replacement bearing (if needed)
- Bearing collar or generator casing

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Remove axle shaft pressed-on bearings and retainers

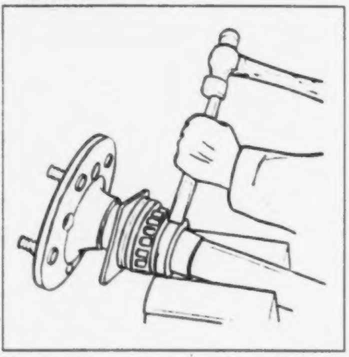
◆ WARNING ◆

Be sure to wear appropriate eye protection while carrying out this procedure.

1. Notice the order of placement of the bearing, retainers, oil seals and gaskets on the axle so they can be reinstalled in the same order.
2. Place the axle shaft securely in a bench vise.
3. Being careful not to damage the axle shaft, use a chisel and hammer to cut four deep grooves equal distances apart around the inner bearing retainer. (Figure 2)
4. If possible, spread the inner retainer and remove it.

   NOTE: The retainer is not always easy to remove at this time. If it won't come off, leave it on—it will come off easily as the bearing is pressed off.

FIGURE 2



Used with permission of Ford Motor Company.

5. Install the bearing remover/installer on the arbor press.
6. The retainer plate and the axle oil seal (if present) should already be positioned against the axle flange. If they're not, move them against the flange.
7. Place the axle shaft in the arbor press, and use Supplement 7, "Removing and Replacing Pressed-on Bearings," to guide you in removing the bearing.

   NOTE: The arbor press's bearing remover/installer should be installed so that it presses squarely on the bearing's inner race.

   ♦ WARNING ♦

   Be sure to place a bearing collar or a generator casing around the bearing while it is being pressed off to protect you in case the bearing explodes during removal.

8. Use the arbor press to press the bearing off the axle.
9. Slip off the retainer plate and the axle oil seal (if present).
10. Repeat the procedure for the other axle.

PROCEDURE

Replace axle shaft pressed-on bearings and retainers

NOTE: Check rear axle shaft runout (Job Sheet 21) before replacing the rear axle shaft bearings and retainers.

1. Wipe the axles clean with a rag.
2. Inspect the axle surfaces for rust, burrs, or rough spots.
3. Use a crocus cloth to smooth imperfections at the area on the axle where the bearing and seal will be installed.
4. Check the replacement bearings to make sure they meet the specifications in the vehicle's service manual.
5. Coat the axle with a small amount of rear axle lubricant.
6. Replace the retainer plate and oil seal on the axle shaft in the correct positions.
7. Follow the manufacturer's recommendations regarding lubrication of the bearing before installation.

8. Use the arbor press with the bearing installer/remover to press the bearing onto the axle shaft. (See Supplement 7, "Removing and Replacing Pressed-on Bearings.")

CAUTION

Do not attempt to press on the bearing and the retainer at the same time.

NOTE: Make sure the correct side of the bearing is facing the retainer, and the bearing installer is correctly positioned to apply pressure to the inside race of the bearing.

9. Use the arbor press to press the retainer onto the shaft, seating it firmly against the bearing.

10. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB
SHEET 20

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 13T

Replace rear axle shafts.

INTRODUCTION

When differential and drive axle service and repair is complete, the rear axle shafts must be replaced before the vehicle can be road tested. The method used to replace the axle shafts depends on whether the shafts are supported by a C-lock or a retainer plate.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Shop towels
- Crocus cloth
- Combination wrenches
- Torque wrench
- Rear axle lubricant

For axles secured by retainer plates, you will also need:

- New gasket(s) for retainer plates
- Soft-faced mallet
- Silicone sealant

> **CAUTION**
> **Always** check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported and the differential reinstalled in the axle housing. (Job Sheet 16) All bearings, seals, and retainers should be reinstalled on the axle. (Job Sheet 18 or 19) If the axles are secured by C-locks, the axle housing cover should be off the housing.

PROCEDURE

Replace rear axles secured by C-locks

1. Wipe the axles clean with a shop towel.
2. Inspect the axle surfaces for rust, burrs, or rough spots.
3. Smooth imperfections with a crocus cloth.
4. Coat the axles with a small amount of rear axle lubricant.
5. Rotate the differential case to expose the differential pinion shaft lock bolt.

6. Use an appropriate wrench to carefully remove the differential pinion shaft lock bolt.

CAUTION

Differential pinion shaft lock bolts break easily.

7. Remove the differential pinion shaft.

CAUTION

Avoid rotating the axle shaft or the differential case while the differential pinion shaft is out—the differential case components will fall apart.

8. Slide the axle shaft squarely into the axle housing, making sure the splines do not damage the axle oil seal.

9. Engage the splines on the axle shaft with the splines of the differential side gear and press inward until the end of the axle shaft can be seen inside the differential case.

10. Install the C-lock in the groove on the inside end of the axle shaft.

11. Check the fit of the C-lock on the axle shaft to make sure the C-lock is not worn and needs to be replaced.

    NOTE: The C-lock should fit on the shaft with no wobble.

12. Pull out on the axle shaft flange to seat the C-lock in the axle side gear.

13. Repeat the procedure for the other axle.

14. Replace the differential pinion shaft.

15. Replace the differential pinion shaft lock bolt and torque to specification.

16. Measure axle shaft flange runout and shaft end play before closing the axle housing and reinstalling the wheels. (Job Sheet 21)

17. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

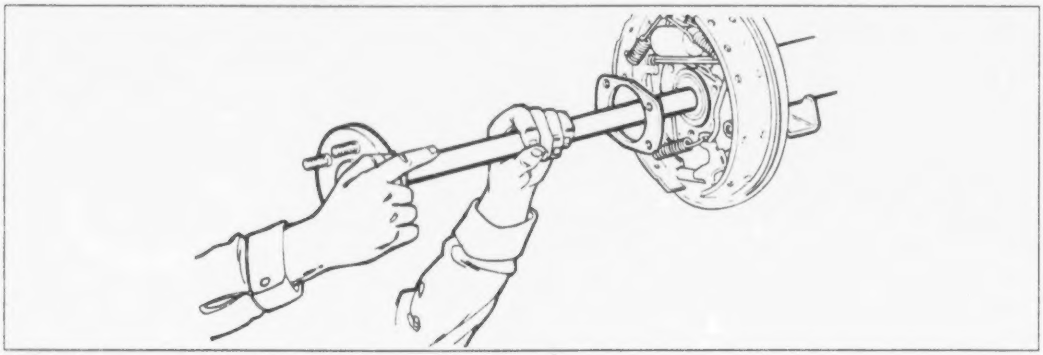
PROCEDURE

Replace axles secured by retainer plates

NOTE: Axle shaft surfaces should have been inspected and serviced before the oil seals, bearings, and retainers were installed.

1. Make sure all old gasket material has been removed from the face of the axle housing.
2. Place a new gasket on the face of the axle housing shaft and hold in place with a thin film of silicone sealant.
3. Install the brake backing plate and brake assembly over the axle housing studs.
4. Place the outer gasket over the axle housing studs.
5. Lubricate the splines on the axle shaft as recommended by the manufacturer.
6. Slide the axle shaft squarely into the axle housing, making sure the splines do not damage the axle oil seal. (Figure 1)

FIGURE 1



Used with permission of Ford Motor Company

7. Start the axle splines into the side gears.
8. Rotate the retainer plate to match the holes in the plate with the axle housing studs.
9. Push the axle splines into the differential side gear until the axle stops.

   NOTE: Some axles require that the axle be tapped gently into place with a soft-faced mallet.

10. Install the retainer plate nuts and torque to specifications, following the appropriate tightening sequence.

11. Repeat the procedure for the other axle.
12. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB
SHEET 21

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES II

OBJECTIVE 13U

Measure rear axle and axle flange runout and shaft end play and complete differential and rear drive axle service.

INTRODUCTION

Drive axle or axle flange runout is present when the surface of the axle shaft or axle flange is uneven, causing the rear axle to wobble as it rotates. Even though this condition seldom causes axle vibration, it can cause wear on parts, and it is best to eliminate any possibility of this problem by checking rear axle and axle flange runout whenever the rear axle is removed. A dial indicator is used to measure rear axle flange runout at five points: (1) the flange pilot, (2) the flange face, and (3-5) the middle and both ends of the axle shaft.

Axle shaft end play is the in-and-out movement of the axle shaft inside the axle housing. Although some shaft end play is desirable, too much can cause extra wear on axle and differential parts. Axle shaft end play is always checked and adjusted before the shaft installation is completed and the test drive made.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, Unit 1, ***Using a Dial Indicator***
- Eye protection
- Dial indicator
- Approved cleaning solvent
- Shop towels
- Crocus cloth
- Jack stand or other movable support
- V-blocks
- Pencil and paper
- Soft-faced mallet
- Axle shaft shims or adjusters (if required)
- Rear axle lubricant and additives as recommended by the manufacturer
- Lube gun, syringe, or suction gun

If the vehicle has an integral carrier, you will also need:

- Thread-locking compound
- Combination wrenches
- Torque wrench
- Putty knife
- New rear cover gasket or sealant

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be properly raised and supported and the wheels and brake drums should be removed from the axles. Axle bearings, retainers, seals, and gaskets should be removed from the axle. (Job Sheet 18 or 19) If the axles are secured by C-locks, the axle housing cover should be off the housing.

PROCEDURE

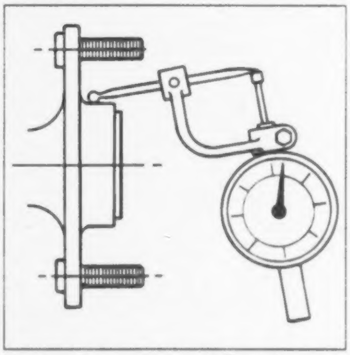
Measure rear axle and axle flange runout

1. Make sure the axle shaft is clean and smooth.
2. Mount the shaft on V-blocks.
3. Attach the dial indicator to a jack stand or other movable support and position the indicator at the middle of the axle shaft with the indicator plunger at a right angle to the shaft diameter.
4. Use Supplement 8, Unit 1, "Using a Dial Indicator," to measure the runout.
5. Repeat this procedure with the dial indicator positioned alternately at either end of the axle shaft.
6. Note the runout measurements.
7. Follow correct procedures to install all axle bearings, retainers, seals, and gaskets. (Job Sheet 18 and 19)
8. Follow correct procedures to install the axle in the axle housing. (Job Sheet 20)
9. Use a crocus cloth to clean any dirt or rust from the outside face of the axle flange.

   NOTE: Rub lightly—excessive polishing may itself cause flange runout.

10. Position the dial indicator plunger against the pilot diameter of the axle flange. (Figure 1)
11. Use Supplement 8, Unit 1, "Using a Dial Indicator," to measure the runout.

FIGURE 1



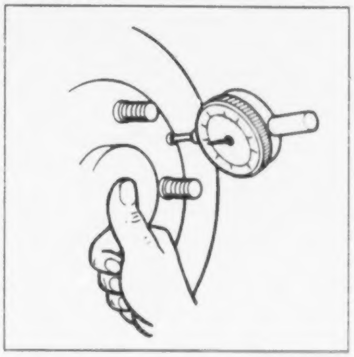
Used with permission of Ford Motor Company.

12. Use a crocus cloth to clean any dirt or rust from the back of the axle flange.

13. Position the dial indicator plunger at a right angle to the flange back just outside the bolt circle. (Figure 2)

14. Use Supplement 8, Unit 1, "Using a Dial Indicator," to measure the runout, placing your thumb on the center of the shaft to eliminate end play as you rotate the shaft.

FIGURE 2



Used with permission of Ford Motor Company.

15. Compare the runout readings with the manufacturer's allowable specifications.

16. If the axle or axle flange runout is not within specifications, replace the axle shaft.

PROCEDURE

Measure rear axle shaft end play

1. Hit the axle shaft end squarely with a soft-faced mallet to seat the axle bearing.

2. Mount a dial indicator on the brake backing plate with the indicator plunger at a right angle to the face of the axle flange.

3. Use Supplement 8, Unit 1, "Using a Dial Indicator," to measure the runout as you use the axle flange to push and pull the axle shaft in and out.

4. Repeat the measurement procedure on the other axle.

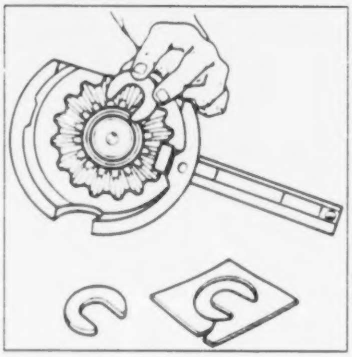
5. Compare the dial indicator readings with the manufacturer's allowable end play specification.

6. On axles secured by retainer plates, add or subtract axle shims or adjusters between the retainer plate and the end of the axle housing to increase or decrease the end play.

   NOTE: Manufacturers recommend that the axle be replaced on some vehicles if shaft end play is not within specifications.

7. On axles secured by C-locks, make a shim the same shape as the C-lock and install it between the C-lock and the differential side gear to increase or decrease the end play. (Figure 3)

FIGURE 3



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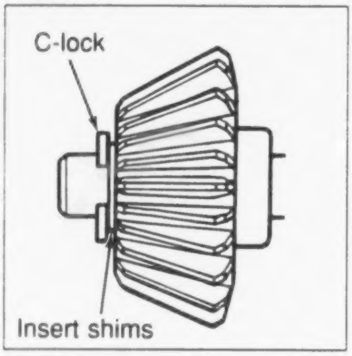
8. After installing shims, re-check axle end play. (Figure 4)

9. Make further adjustments and re-check end play if the initial adjustments did not bring the end play within specifications.

FIGURE 4



Used with permission of Ford Motor Company.

PROCEDURE

Complete differential and rear drive axle service on an integral carrier

1. Reinstall the differential pinion shaft.
2. Apply thread-locking compound to the differential pinion shaft lock bolt and torque it to manufacturer's specifications.
3. Use a putty knife to remove the old gasket or sealant from the rear cover.
4. Clean the cover's sealing surface with an approved cleaning solvent.
5. Position the new gasket or sealant according to manufacturer's recommendations.

6. Replace the rear cover and tighten the cover bolts to torque specifications, using a star pattern.

7. Replace the brake drums and wheels.

CAUTION

If the bearing grease or rear axle lubricant has been leaking, check the brake lining for possible contamination. Brake linings cannot be cleaned, they must be replaced.

8. Add the lubricant and additives specified by the vehicle manufacturer to the recommended height using a lube gun, syringe, or suction gun.

9. Replace and tighten the fill plug; torque to specifications if appropriate.

10. Lower the vehicle on the hoist.

11. Test drive the vehicle to evaluate repairs and service.

12. Make any needed adjustments.

13. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Complete differential and rear drive axle service on a removable carrier

1. Replace the brake drums and wheels.

CAUTION

If the bearing grease or rear axle lubricant has been leaking, check the brake lining for possible contamination. Brake linings cannot be cleaned, they must be replaced.

2. Add the lubricant and additives specified by the vehicle manufacturer to the recommended height using a lube gun, syringe, or suction gun.

3. Replace and tighten the fill plug; torque to specifications if appropriate.

4. Lower the vehicle on the hoist.

5. Test drive the vehicle to evaluate repairs and service.

6. Make any needed adjustments.

7. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PRACTICAL TEST 1

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 1

Inspect the rear axle housing and flush and refill the rear axle lubricant.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared vehicle correctly.	_____	_____
3. Located fill and drain holes.	_____	_____
4. Measured rear axle lubricant level correctly.	_____	_____
5. Drained lubricant using outlined procedures.	_____	_____
6. Refilled lubricant correctly.	_____	_____
7. Determined and used correct lubrication specifications throughout procedure.	_____	_____
8. Completed service correctly.	_____	_____
9. Observed safety rules and precautions.	_____	_____
10. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2 — SERVICE DIFFERENTIALS AND REAR DRIVE AXLES — II

JOB SHEET 2 **Remove rear axle shafts.**

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again. [**Alternate steps for axle shafts secured by retainer plates are in brackets.**]

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared vehicle correctly.	_____	_____
3. Drained lubricant and opened axle housing using correct procedures. [Removed retainer plate nuts correctly.]	_____	_____
4. Removed and replaced differential pinion shaft bolt and differential pinion shaft using outlined procedure. [Removed axle shaft using outlined procedure.]	_____	_____
5. Removed axle C-lock and axle correctly. [Removed and wired brake backing to vehicle frame.]	_____	_____
6. Completed service correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 3

Measure ring gear runout.

STUDENT'S NAME ______________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Positioned dial indicator on ring gear correctly.	_____	_____
3. Measured ring gear runout according to outlined procedures.	_____	_____
4. Calculated the ring gear runout accurately.	_____	_____
5. Located the ring gear runout specification in the vehicle service manual and correctly identified any further measurements needed.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 4

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 4

Check ring gear tooth contact patterns.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared differential components and ring gear correctly.	_____	_____
3. Set load on drive pinion gear correctly.	_____	_____
4. Obtained ring gear tooth contact patterns following outlined procedures.	_____	_____
5. Used the results of the ring gear tooth contact pattern to diagnose needed differential adjustments.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 5

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 5

Measure and adjust side bearing preload and ring to pinion gear backlash.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared vehicle correctly.	_____	_____
3. Measured ring gear backlash according to outlined procedures.	_____	_____
4. Tested differential side bearing preload correctly.	_____	_____
5. Adjusted differential side bearing preload using the correct procedure for the vehicle.	_____	_____
6. Adjusted the ring gear backlash to vehicle specifications, using the correct procedure for the vehicle.	_____	_____
7. Re-checked adjustments at the appropriate stages.	_____	_____
8. Completed service correctly.	_____	_____
9. Observed safety rules and precautions.	_____	_____
10. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 6

DIFFERENTIAL AND REAR DRIVE AXLES

II

JOB SHEET 6

Remove, inspect, and replace a companion flange and pinion seal.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared vehicle correctly.	_____	_____
3. Measured drive pinion bearing preload correctly.	_____	_____
4. Removed companion flange correctly.	_____	_____
5. Removed pinion seal following outlined procedures.	_____	_____
6. Inspected and prepared differential housing bore, companion flange, and drive pinion shaft correctly.	_____	_____
7. Installed pinion seal correctly.	_____	_____
8. Installed companion flange following outlined procedures.	_____	_____
9. Set pinion bearing preload correctly.	_____	_____
10. Checked pinion bearing preload and ring gear tooth contact pattern to make sure adjustments were not needed.	_____	_____
11. Observed safety rules and precautions.	_____	_____

12. Cleaned work area and returned equipment and materials to proper storage. ____ ____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 7

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 7

Remove the differential case assembly and clean and inspect the differential housing.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared vehicle correctly.	_____	_____
3. Removed carrier from a removable carrier housing following outlined procedures.	_____	_____
4. Correctly marked and prepared differential case assembly parts for removal.	_____	_____
5. Removed differential case assembly correctly, keeping parts for the right and left sides of the differential case assembly together.	_____	_____
6. Cleaned and inspected the differential housing correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 8

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 8

Remove, inspect, and replace a ring gear.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed ring gear following outlined procedures.	_____	_____
3. Inspected ring gear correctly.	_____	_____
4. Checked ring gear and differential case runout with manufacturer's specifications before replacing the ring gear.	_____	_____
5. Replaced the ring gear following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 9

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 9

Measure differential case runout.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Cleaned and prepared differential case correctly.	_____	_____
3. Positioned the differential case on the V-blocks correctly.	_____	_____
4. Positioned the dial indicator for the test correctly.	_____	_____
5. Measured differential case runout following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 10
SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 10

Remove, inspect, and replace differential side bearings.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Cleaned and inspected the side bearings correctly.	_____	_____
3. Removed the side bearings correctly.	_____	_____
4. Used outlined procedures to prepare the differential case for the installation of the side bearings.	_____	_____
5. Installed the side bearings correctly.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

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____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 11

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 11

Remove, inspect, measure, adjust, and replace the parts of a conventional differential case assembly.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Measured side gear and differential pinion gear backlash correctly.	_____	_____
3. Removed the differential case assembly parts following outlined procedures.	_____	_____
4. Cleaned and inspected all parts correctly.	_____	_____
5. Replaced differential case assembly parts following outlined procedures.	_____	_____
6. Aligned all match marks correctly on reassembly.	_____	_____
7. Remeasured and adjusted for side gear and differential pinion gear backlash correctly.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 12

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 12

Remove, inspect, measure, adjust, and replace limited-slip differential components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared and marked differential components correctly.	_____	_____
3. Removed differential components following outlined procedures.	_____	_____
4. Cleaned and inspected components correctly.	_____	_____
5. Replaced and adjusted components following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 13 — SERVICE DIFFERENTIALS AND REAR DRIVE AXLES — II

JOB SHEET 13 — **Remove and inspect a drive pinion gear assembly.**

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed drive pinion gear following outlined procedures.	_____	_____
3. Removed drive pinion bearing races correctly.	_____	_____
4. Removed rear drive pinion bearing cone correctly.	_____	_____
5. Measured rear depth shim correctly.	_____	_____
6. Cleaned and inspected drive pinion assembly parts following outlined procedures.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 14

Measure and adjust drive pinion depth.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the differential assembly correctly prior to measurement.	_____	_____
3. Installed drive pinion depth gauge according to instructions.	_____	_____
4. Measured drive pinion depth correctly.	_____	_____
5. Read the pinion marking and calculated the correct shim width needed for drive pinion depth adjustment.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 15

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 15

Replace drive pinion gear assembly components and measure and adjust drive pinion bearing preload.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Correctly completed all necessary steps before beginning to replace the drive pinion gear assembly.	_____	_____
3. Installed rear drive pinion bearing cone correctly.	_____	_____
4. Assembled drive pinion gear assembly components correctly.	_____	_____
5. Set drive pinion bearing preload following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 16

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 16

Replace and adjust the differential case assembly.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Correctly completed all necessary steps before beginning to replace the differential case assembly.	_____	_____
3. Positioned the ring gear and drive pinion gear teeth to mesh correctly.	_____	_____
4. Correctly completed the measurements and adjustments to the differential case required after the differential case has been installed in the housing.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 17

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 17

Inspect and replace rear axle shaft wheel studs.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Correctly inspected and identified wheel studs which needed replacement.	_____	_____
3. Placed rear axle flange in press correctly.	_____	_____
4. Pressed out old wheel stud correctly.	_____	_____
5. Installed new wheel studs following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 18

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 18 **Remove, inspect, and replace rear axle shaft seals and bearings.**

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION **Evaluator Note:** Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed bearings and seals correctly.	_____	_____
3. Cleaned and inspected bearings according to outlined procedures.	_____	_____
4. Lubricated bearings correctly.	_____	_____
5. Inspected and prepared axle housing according to outlined procedures.	_____	_____
6. Installed bearing correctly.	_____	_____
7. Installed seal correctly.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 19

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 19

Remove and replace axle shaft pressed-on bearings and retainers.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed bearing retainer correctly.	_____	_____
3. Removed bearing following outlined procedures.	_____	_____
4. Prepared axle shaft surface correctly.	_____	_____
5. Pressed on new retainer and bearing following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 20

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

JOB SHEET 20

Replace rear axle shafts.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared axle shaft correctly.	_____	_____
3. Replaced axle shaft according to outlined procedures.	_____	_____
4. Completed service according to outlined procedures.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 21

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

JOB SHEET 21

Measure rear axle and axle flange runout and shaft end play and complete differential and rear drive axle service.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Measured axle shaft runout according to outlined procedures.	_____	_____
3. Measured flange pilot and flange runout correctly.	_____	_____
4. Measured rear axle shaft end play correctly.	_____	_____
5. If required, added or removed shims correctly and made accurate end play adjustments within specifications.	_____	_____
6. Completed service correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation, and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

NAME ______________________________ SCORE ______

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive differential and rear drive axles by selecting the correct definition from four choices. Select the best answer for each term.

______1. **axis**

A. A center line (often imaginary) around which a part rotates
B. The center of a sphere
C. The center of a circle
D. A shaft which meshes with a gear

______2. **backlash** (in gears)

A. A backward movement
B. The space between the bottom of one gear tooth and the valley between the two gear teeth with which the tooth meshes
C. The space between the pitch lines of two meshing gear teeth
D. How far two meshing gears are from each other

______3. **chamfer**

A. A beveled gear
B. A beveled edge
C. The inside edge of an antifriction bearing
D. A gear tooth pattern

______4. **clearance**

A. The space between the bottom of one gear tooth and the valley between the two gear teeth with which the tooth meshes
B. The space between the pitch lines of two meshing gear teeth
C. The proper working contact of gear teeth in a gear set
D. How far two meshing gears are from each other

______5. **drive gear**

A. A gear that is moved by another gear
B. The gear in a gear set that moves first and causes the other gears to move
C. The smaller gear in a gear set
D. The larger gear in a gear set

______6. **driven gear**

A. A gear that is moved by another gear
B. The gear in a gear set that moves first and causes the other gears to move
C. The smaller gear in a gear set
D. The larger gear in a gear set

______7. **gear ratio**

A. The number of gears in a gear set
B. The proper working contact of gears in a gear set
C. A numerical ratio representing the number of turns made by the drive gear to complete one turn of the driven gear
D. A numerical ratio representing the relative size of the gears in a gear set

______8. **gear set**

A. A grouping of matched gears
B. The number of gears used to transfer power
C. A smaller gear meshing with a larger gear
D. Two or more meshing gears

______9. **hunting gear set**

A. A gear set containing two gears
B. Any one tooth of the drive gear contacts only certain driven gear teeth during several revolutions
C. Any one tooth of the drive gear contacts every driven gear tooth after several revolutions
D. A gear set in which a drive gear moves more than one other gear

_____10. **matched gear set code**

A. A code stamped on each gear in a gear set which enables the gears to be properly matched
B. A code stamped on the axle housing which identifies the size gears used in that differential
C. A code stamped on a gear which tells the size shim to use to properly match the gears in the gear set
D. A code stamped on each gear in a gear set which gives the size of the gear so it can be matched with other gears in forming a gear set

_____11. **mesh** (in gears)

A. A tight fit between two gears that operate together in a gear set
B. The space between two gears in a gear set
C. A gear set containing a drive gear and one or more driven gears
D. The proper working contact of gear teeth in a gear set

_____12. **nonhunting gear set**

A. A gear set containing two gears
B. Any one tooth of the drive gear contacts only certain driven gear teeth during several revolutions
C. Any one tooth of the drive gear contacts every driven gear tooth after several revolutions
D. A gear set in which a drive gear moves more than one other gear

_____13. **pinion gear**

A. The drive gear in a gear set
B. The smaller or smallest gear in a gear set
C. The larger or largest gear in a gear set
D. The driven gear in a gear set

_____14. **preload** (in bearings)

A. Operating pressure which assures that the bearing is held in the correct operating position
B. Pressure placed on the bearing before the bearing is put under actual operating conditions
C. Two parts fitting together so tightly that special tools are required to force them together or apart
D. The pressure needed in order to correctly make a ring gear tooth contact pattern test

____15. **press fit**

A. Two parts fitting together so tightly that special tools are required to force them together or apart
B. Two parts which must have a gasket or sealant in order to fit together correctly
C. Two parts which have been welded together during the manufacturing process
D. Gears in a gear set which operate together under pressure

_____16. **ring gear**

A. A gear which has gear teeth cut only around part of its face
B. A smaller or smallest gear in a gear set
C. A gear whose teeth are parallel to its axis of rotation
D. The larger or largest gear in a gear set. Also a gear cut on a ring-shaped rim

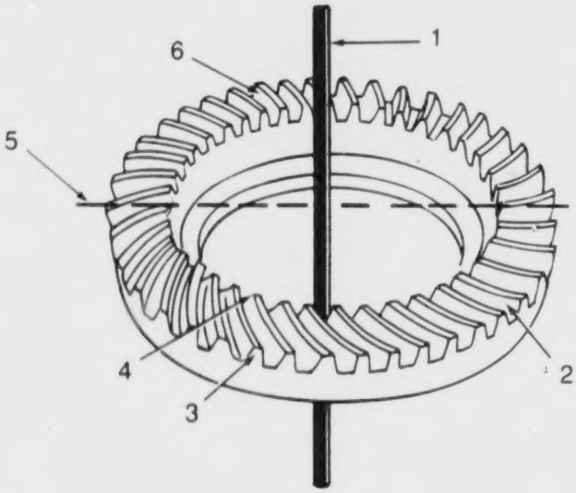
_____17. **specifications**

A. Standard measurements that are applied to the parts of an assembly of all vehicles
B. Standard or nominal procedures used for repair procedures on all vehicles
C. A schematic drawing of a vehicle's operating systems
D. Information provided by a vehicle's manufacturer which should be applied to that vehicle to assure that the vehicle operates properly

OBJECTIVE 2

Match the names of the parts of a gear and a gear tooth to illustrations. Place the letter of the part indicated in the blank. Some letters will be used more than once. Use the following list for both parts of this question.

A. Axis of rotation
B. Centerline
C. Concave (coast) side
D. Convex (drive) side
E. Face
F. Flank
G. Heel
H. Pitch line
I. Toe



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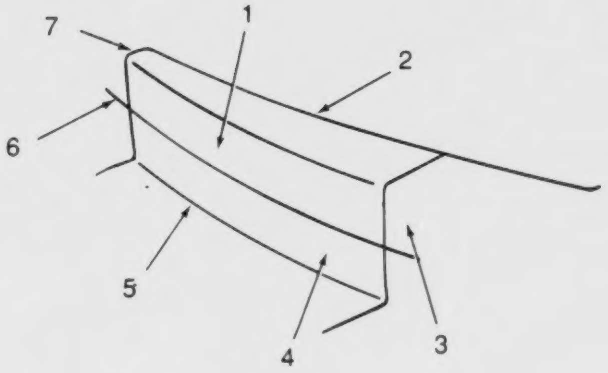
A. **Parts of a Gear** — Write the letter of the gear part indicated in the blank.

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______



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B. **Parts of a Gear Tooth** — Write the letter of the part of the gear tooth indicated in the blank.

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______

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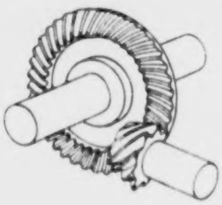
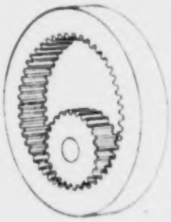
OBJECTIVE 3

Match the names of common gear types with illustrations of the gears. Write the correct name from the following list under the illustration of the gear.

helical gear
hypoid gear
internal gear
rack and pinion gear
spiral bevel gear
spur gear
straight bevel gear
worm gear





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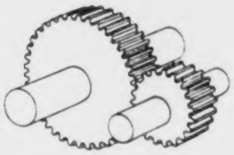
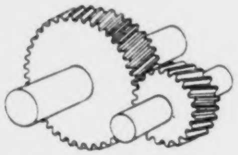
1. ______________________

2. ______________________





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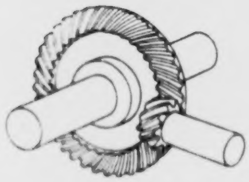
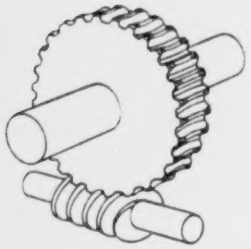
3. ______________________

4. ______________________





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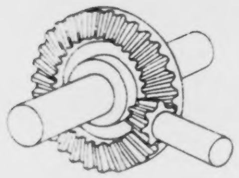
5. ______________________ 6. ______________________



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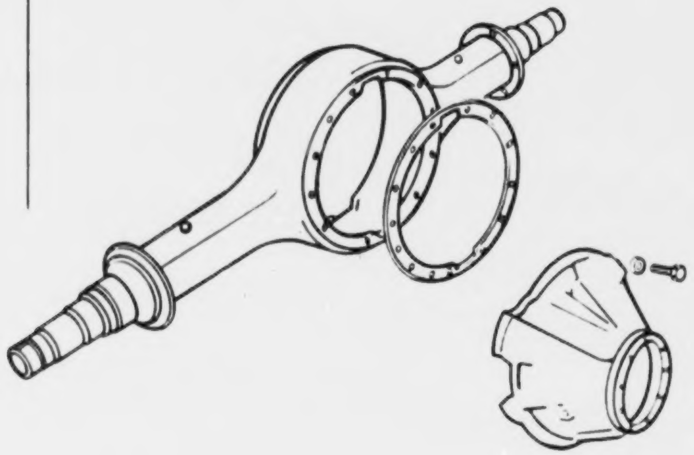
7. ______________________

OBJECTIVE 4 **Label illustrations of the two types of rear axle housings with their correct names.** Write the type of rear axle housing shown in the blank.



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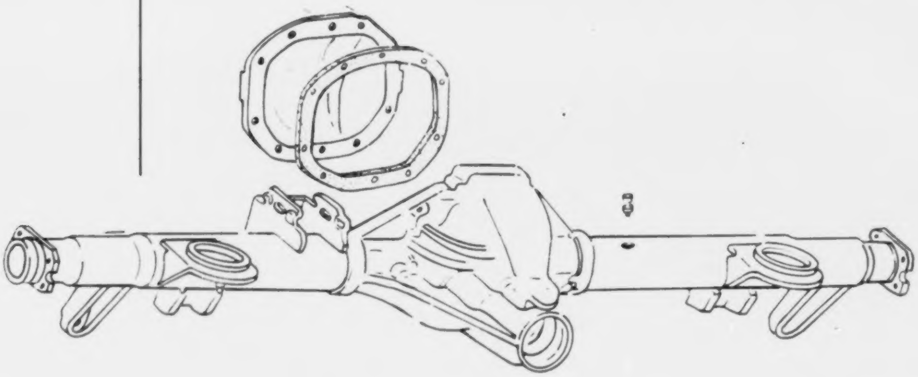
1. Type of axle housing: ______________________



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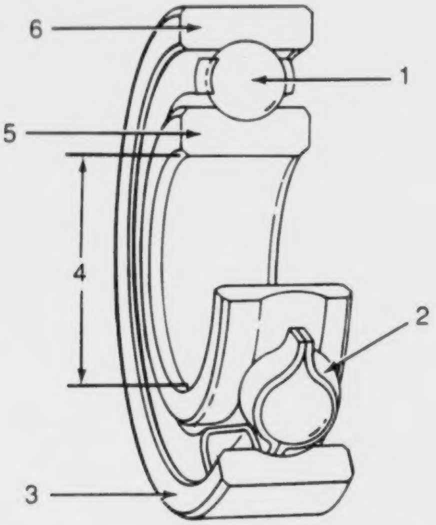
2. Type of axle housing: ______________________

OBJECTIVE 5

Label three types of antifriction bearings and match the names of their parts to illustrations. Write the name of the type of bearing in the large blank and place the letters of the parts indicated in the smaller blanks. Some letters will be used more than once. Use the following list for all parts of this question.

A. Ball
B. Bore
C. Cage or separator
D. Cone
E. Cup
F. Face
G. Inner race
H. Outer race
I. Roller
J. Tapered roller



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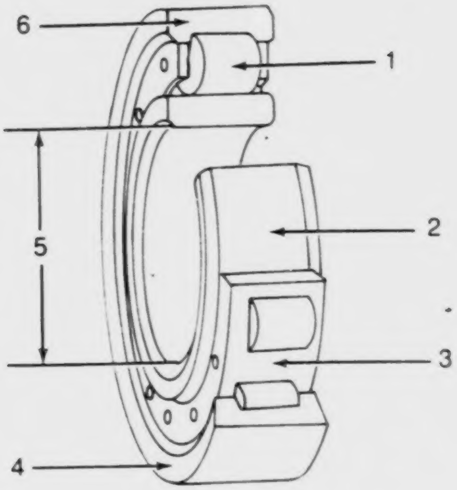
A. Type of bearing: ______________________

Parts:

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______



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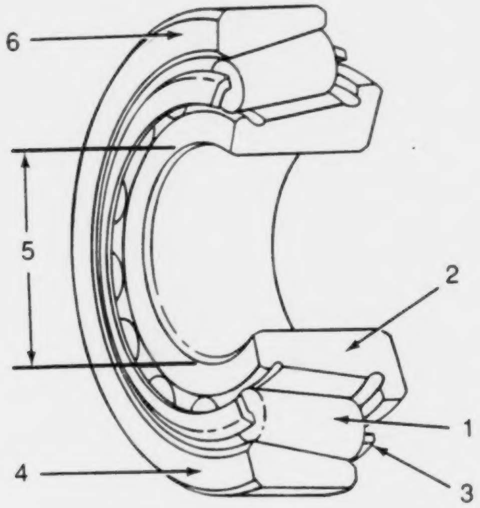
B. Type of bearing: ______________________________

Parts:

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______



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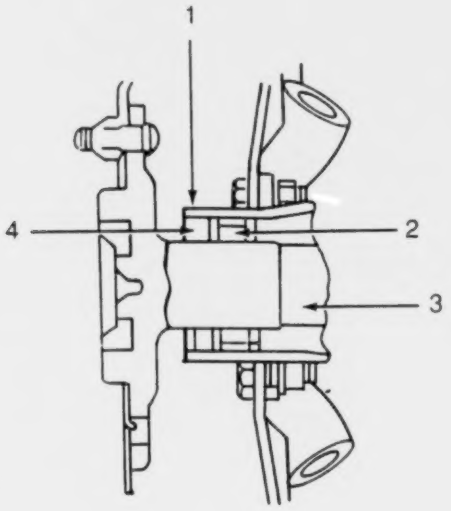
C. Type of bearing: ____________________

Parts:

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______

OBJECTIVE 6

Label the two types of rear drive axles and their parts on illustrations. Write the type of drive axle shown in the first blank and the name of the numbered part in the blank corresponding to the number.



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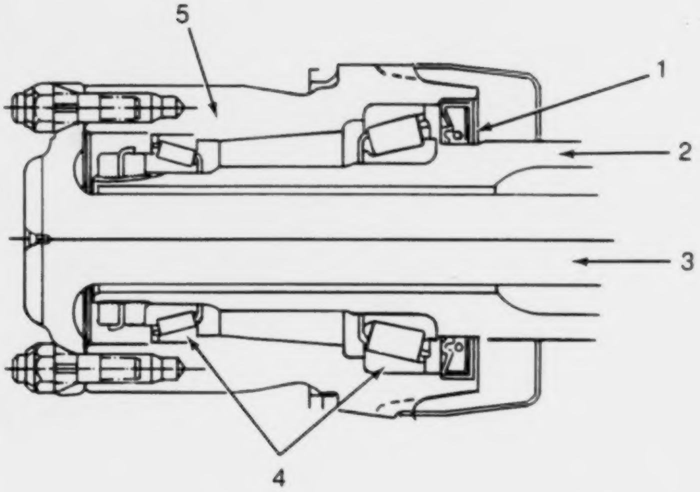
A. Type of rear drive axle: ______________________

1. ______________________
2. ______________________
3. ______________________
4. ______________________



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B. Type of rear drive axle: ____________________

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

OBJECTIVE 7

Write the four functions of a differential. Write the functions in the blanks provided.

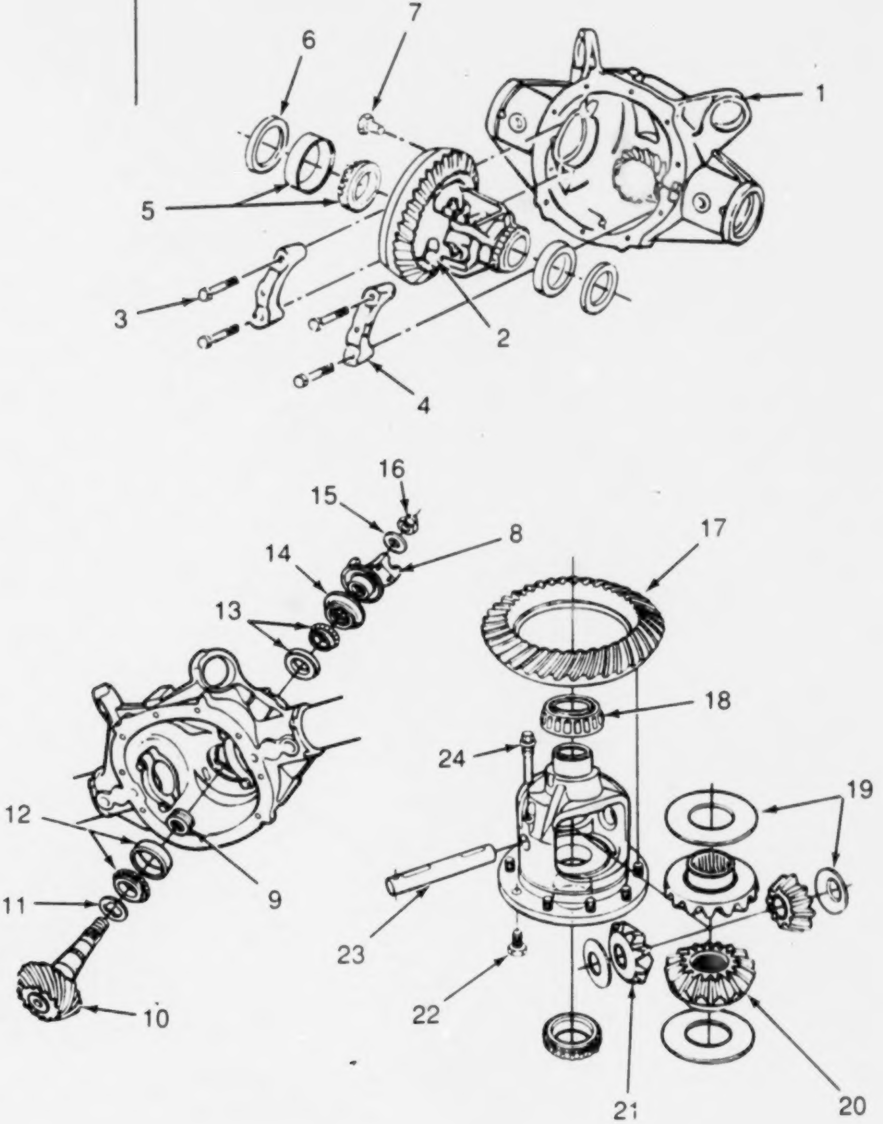
1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

OBJECTIVE 8 **Match the names of the parts of a conventional differential to an illustration.**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Match the name of the part at the right to the location of the part on the illustration. Some items will be used more than once.

______1.
______2.
______3.
______4.
______5.
______6.
______7.
______8.
______9.
______10.
______11.
______12.
______13.
______14.
______15.
______16.
______17.
______18.
______19.
______20.
______21.
______22.
______23.
______24.

A. Axle housing
B. Collapsible spacer
C. Companion flange
D. Depth shim
E. Differential case
F. Differential pinion gear
G. Differential pinion shaft
H. Differential side bearing
I. Differential side gear
J. Drive pinion gear
K. Front drive pinion bearing
L. Pinion nut
M. Pinion seal
N. Pinion shaft bolt
O. Rear drive pinion bearing
P. Ring gear
Q. Ring gear bolt
R. Shim
S. Side bearing cap
T. Side bearing cap bolt
U. Thrust washer
V. Washer

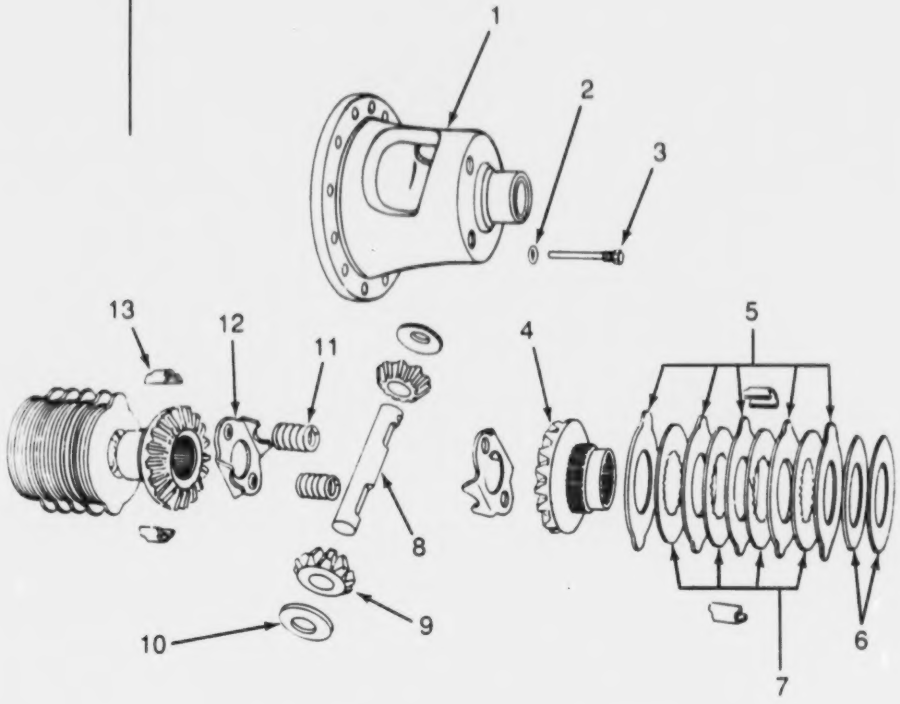
OBJECTIVE 9

Distinguish between the functional operation of a conventional and a limited-slip differential. Write "conventional" or "limited slip" in the blank below which best describes the operation of that type of differential.

Under conditions where a vehicle's two drive wheels have significantly different traction (when, for example, one wheel is on ice) . . .

1. A ____ differential will divide the available turning power evenly between both drive wheels.
2. A ____ differential will provide most or all available turning power to the wheel with the **least** amount of traction.

OBJECTIVE 10 **Label two main types of limited slip differentials and match the names of their parts to illustrations.** Write the type of limited slip differential shown in the blank provided.



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A. Type of limited-slip differential: ____________________

Place the letter of the part indicated in the blank. Parts may be used once, more than once, or not at all.

_______1.

_______2.

_______3.

_______4.

_______5.

_______6.

_______7.

_______8.

_______9.

_____10.

_____11.

_____12.

_____13.

A. C-lock

B. Case cap half

C. Case flange half

D. Clutch disc guide

E. Cone and side gear

F. Differential case

G. Differential case bolt

H. Differential pinion gear

I. Differential pinion shaft

J. Differential pinion shaft lock bolt

K. Differential side gear

L. Preload plate

M. Preload springs

N. Shims

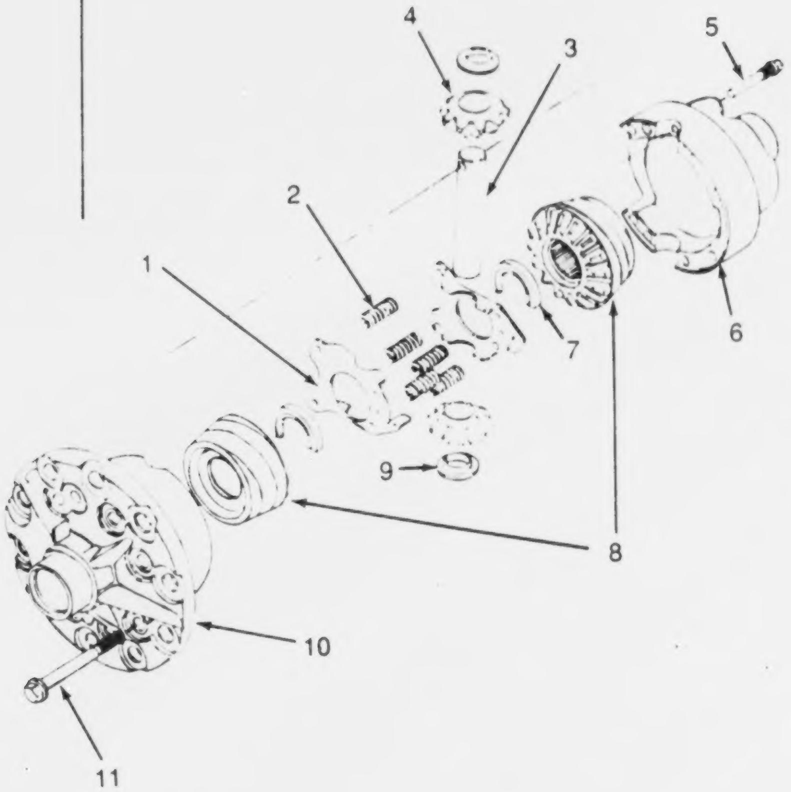
O. Splined clutch discs

P. Steel eared clutch plates

Q. Thrust plate

R. Thrust washer

S. Washer


4
3
5
2
1
7
6
9
8
10
11

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B. Type of limited-slip differential: ______________________

Place the letter of the part indicated in the blank. Parts may be used once, more than once, or not at all.

_______1.

_______2.

_______3.

_______4.

_______5.

_______6.

_______7.

_______8.

_______9.

______10.

______11.

A. C-lock

B. Case cap half

C. Case flange half

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M. Preload springs

N. Shims

O. Splined clutch discs

P. Steel eared clutch plates

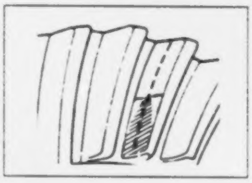
Q. Thrust plate

R. Thrust washer

S. Washer

OBJECTIVE 11

Determine needed differential adjustments by examining illustrations of ring gear tooth contact patterns. Circle the adjustment required by the gear tooth pattern illustrated.



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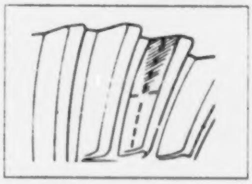
1. A. Increase drive pinion shim thickness

   B. Decrease drive pinion shim thickness

   C. Increase backlash

   D. Decrease backlash

   E. No adjustment necessary



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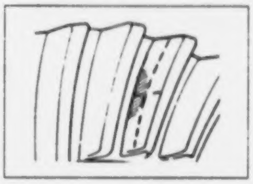
2. A. Increase drive pinion shim thickness

   B. Decrease drive pinion shim thickness

   C. Increase backlash

   D. Decrease backlash

   E. No adjustment necessary



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3. A. Increase drive pinion shim thickness

   B. Decrease drive pinion shim thickness

   C. Increase backlash

   D. Decrease backlash

   E. No adjustment necessary

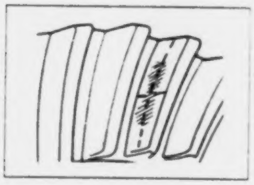
4. A. Increase drive pinion shim thickness

   B. Decrease drive pinion shim thickness

   C. Increase backlash

   D. Decrease backlash

   E. No adjustment necessary



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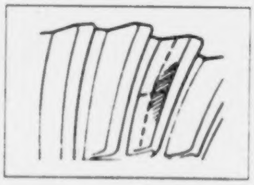
5. A. Increase drive pinion shim thickness

   B. Decrease drive pinion shim thickness

   C. Increase backlash

   D. Decrease backlash

   E. No adjustment necessary



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WRITTEN TEST ANSWERS

SERVICE DIFFERENTIALS AND REAR DRIVE AXLES

II

OBJECTIVE 1

1. A
2. C
3. B
4. A
5. B
6. A
7. C
8. D
9. C
10. A
11. D
12. B
13. B
14. B
15. A
16. D
17. D

OBJECTIVE 2

A. **Parts of a Gear**

1. A
2. D
3. G
4. I
5. B
6. C

B. **Parts of a Gear Tooth**

1. E
2. C
3. G
4. F
5. D
6. H
7. I

OBJECTIVE 3

1. Hypoid gear
2. Internal gear
3. Spur gear
4. Helical gear
5. Spiral bevel gear
6. Worm gear
7. Straight bevel gear

OBJECTIVE 4

1. Removable carrier (separable carrier or banjo housing)
2. Integral carrier (unitized carrier)

OBJECTIVE 5

A. Ball bearing

1. A
2. C
3. F
4. B
5. G
6. H

B. Roller bearing

1. I
2. G
3. C
4. F
5. B
6. H

C. Tapered roller bearing

1. J
2. D
3. C
4. F
5. B
6. E

OBJECTIVE 6

A. Semi-floating axle

1. Axle housing
2. Bearing
3. Axle shaft
4. Oil seal

B. Full-floating axle

1. Oil seal
2. Axle housing
3. Axle shaft
4. Bearings
5. Wheel hub

OBJECTIVE 7

The answer should include all of the following:

- Changes the direction of driveline turning power 90°
- Divides the power between the two drive axles
- Adjusts the amount of power transmitted to each drive axle as the vehicle turns a corner
- Allows one final gear reduction, reducing the speed and increasing the power of the engine torque

OBJECTIVE 8

1. A
2. E
3. T
4. S
5. H
6. R
7. Q
8. C
9. B
10. J
11. D
12. O
13. K
14. M
15. V
16. L
17. P
18. H
19. U
20. I
21. F
22. Q
23. G
24. N

OBJECTIVE 9

1. Limited slip
2. Conventional

OBJECTIVE 10

A. Clutch plate type

1. F
2. S
3. J
4. K
5. P
6. N
7. O
8. I
9. H
10. R
11. M
12. L
13. D

B. Cone type

1. Q
2. M
3. I
4. H
5. J
6. B
7. A
8. E
9. R
10. C
11. G

OBJECTIVE 11

1. C
2. D
3. B
4. E
5. A

OBJECTIVE SHEET

SERVICE CLUTCHES

III

INTRODUCTION

Located between the engine and the transmission or transaxle, the clutch is the only drivetrain component that is found *only* in vehicles which have a manual transmission or transaxle. Vehicles with an automatic transmission have a fluid coupling or torque converter which performs the clutch's function of connecting and disconnecting the drivetrain to the engine's turning power. Although the transmission must be removed before the clutch can be serviced, many transmission problems begin with a faulty clutch. This unit examines the clutch system in a front-engine, rear-wheel drive vehicle.

PREREQUISITE

Before studying this unit, the student must have successfully completed Unit 2, *Servicing Differentials and Rear Drive Axles.*

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose clutch problems and service and repair the clutch. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Choose the correct definitions for terms associated with the automotive clutch by selecting the correct definition from four choices.
2. Label the major components of the clutch system on an illustration.
3. Match the names of clutch components to phrases describing the components or giving their functions.
4. Identify the operating condition of the major clutch components in both the engaged and the disengaged positions.

5. Match the names of the parts of a flywheel to an illustration.

6. Label three types of pressure plate assemblies and match the names of their parts to illustrations.

7. Match the names of the parts of a clutch disc to illustrations.

8. Label three types of clutch linkages and match the names of their parts to illustrations.

9. Label the parts involved in the clutch release mechanism on an illustration.

10. Diagnose clutch noise and performance problems. (Assignment Sheet 1)

11. Demonstrate the ability to:

    A. Inspect, adjust, and replace rod and lever type clutch linkage components. (Job Sheet 1)

    B. Inspect, adjust, and replace cable type clutch linkage components. (Job Sheet 2)

    C. Inspect, adjust, repair, and replace hydraulic clutch components. (Job Sheet 3)

    D. Remove the transmission and clutch housing. (Job Sheet 4)

    E. Remove, inspect, adjust, and replace the release bearing, release fork, and pivot. (Job Sheet 5)

    F. Remove, inspect, and replace the pressure plate assembly and clutch disc. (Job Sheet 6)

    G. Remove, inspect, and replace the pilot bushing or bearing. (Job Sheet 7)

    H. Inspect, remove, repair, service, and replace the flywheel and ring gear. (Job Sheet 8)

    I. Measure crankshaft end play and flywheel runout. (Job Sheet 9)

    J. Inspect the engine block, clutch housing, and transmission housing mating surfaces. (Job Sheet 10)

    K. Measure clutch housing face runout and clutch housing bore runout. (Job Sheet 11)

    L. Replace the clutch housing and transmission. (Job Sheet 12)

PREPARATION

Review unit and plan presentation

- Study the specific objectives to determine the order in which you will present the objectives. Decide whether or not you wish to add additional objectives.
- Review teaching suggestions given in the Delivery section and plan classroom activities.
- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.
- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distractors for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

Obtain supplemental materials

- Order films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrates job sheet skills. Videotape your own procedures if unable to obtain suitable media.
- Copies of current articles on subjects covered in this unit may be obtained by writing to the *Automotive Information Council's* Reference Center. They will also conduct a computer search for such articles. See the note in the section on Media for more information about this free service.
- Obtain competency profiles for this unit.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364, 1-800-522-5810, ext. 589 in-state; 1-800-654-4502 out-of-state.

- Note equipment and material needs for completing job sheets.

Prepare classroom and shop

- Display safety signs, posters, and charts that show clutch components and service, etc.
- Have magazine articles, specification guides, service manuals, mock-ups, and other references about the clutch available for student use.
- Check tools and equipment against job sheet requirements.

Administer Pretest

- Administer pretest.
- Use the pretest results to assess student competencies, considering the results as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the introduction to the unit in the Objective Sheet.
- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive Drivetrain and Axles Specialist.
- Raise a front-engine, rear-wheel drive vehicle on a hoist and show the students the components covered by this unit. Use this opportunity to show them the method that will be used in your shop for exposing a vehicle's clutch system for service.
- Discuss with the students the fact that the material in this unit applies to vehicles which have a front-engine and a rear-wheel drive. Show them the location of the clutch on several vehicles, including a front-wheel drive vehicle. Try to include vehicles with various types of clutch access.
- Explain that basic information learned in this unit will also be applied later in units which apply to front-wheel drive and four-wheel drive vehicles.

- Show the students that the job sheets in the unit are normally listed in the order they must be performed. Some tasks must be performed before others can be performed successfully. **This order is important** in the classroom and on the job. However, because procedures on different vehicles vary, the vehicle's service manual should always be consulted to assist in identifying the proper diagnosis, service, or repair sequence. Assist the students to identify the logic in this order as you work through the unit.

- Look at one of the later job sheets. Discuss the fact that the preparation and procedures that need to be completed before beginning the job sheet are described before the procedures are listed. The job sheet number in parentheses refers to the job sheet which will instruct them how to perform that preliminary preparation or procedure.

Objective 1 Choose the correct definitions for terms associated with the automotive clutch by selecting the correct definition from four choices.

- Show examples or demonstrate terms where applicable.

- Explain that students will find that these terms are sometimes used differently in different service manuals and automotive materials.

Objective 2 Label the major components of the clutch system on an illustration.

- Show the filmstrip, *The Automotive Clutch Assembly*, parts 1 & 2—"Basic Parts and Their Operation" and "Power Flow."

- Show the students examples of the major clutch components on a vehicle.

- Discuss the fact that the part of the clutch system located in the clutch housing is often informally called the "clutch assembly," but that the clutch housing and clutch linkage are also part of the clutch system.

Objective 3 Match the names of clutch components to phrases describing the components or giving their functions.

- If the shop has vehicles with different types of clutch housings, raise these vehicles and show the students the different types of clutch housings. Point out their various features—advantages, and disadvantages.

- Point out any ventilation features on the clutch housings. Discuss their purpose and any service they might need.

- Put actual clutch system components on a table or workbench as you discuss the material in Objective 3.
- Encourage the students to handle the different components.
- Roughly assemble the clutch components as you discuss their functions, showing the students how the parts fit together.

Objective 4 Identify the operating condition of the major clutch components in both the engaged and the disengaged positions.

- Discuss the meaning of the terms *engaged* and *disengaged* as related to the clutch, stressing that driver involvement is necessary only to *disengage* the clutch.
- Have the students make a list of driving situations which require that the clutch be disengaged. For example: changing gears, starting the vehicle, etc.
- Use actual clutch components to demonstrate the position of the various components when the clutch is engaged and disengaged. Begin with the position of the clutch pedal and work through each component as it is involved.
- Explain the boxed material on "Clutch Spin Time."

Objective 5 Match the names of the parts of a flywheel to an illustration.

- Display several different flywheels and point out the parts on each, discussing the reasons for the flywheel's weight and the materials used in its manufacture.
- Point out the fact that flywheel bolts are made of special hardened steel and that the original bolts are reused rather than replaced, unless they are damaged.
- Review the functions of the flywheel.
- Show how the flywheel is bolted to the crankshaft and describe the role of the crankshaft as a part of the engine.
- Discuss how components are joined in a *shrink fit*, stressing that when metal is heated it *expands* and when it is cooled, it *contracts*.
- Point out the fact that the ring gear is not machined on the flywheel but is a separate part and can be replaced separately.

Objective 6 Label three types of pressure plate assemblies and match the names of their parts to illustrations.

- Display examples of the different types of pressure plate assemblies and point out the parts on each.
- Discuss the difference between a *pressure plate* and a *pressure plate assembly*.
- Review the functions of the pressure plate assembly.
- Use an actual release bearing to demonstrate how each type of pressure plate assembly is disengaged.
- Discuss the meaning of *centrifugal force*.
- In talking about the semi-centrifugal type pressure plate assembly, review situations in which additional assistance might be needed to disengage the clutch.
- Explain the boxed material on "Roller Type Semi-Centrifugal Pressure Plate Assembly."
- Display actual examples or posters of damaged and worn pressure plate assemblies and discuss the causes of the wear and damage.

Objective 7 Match the names of the parts of a clutch disc to illustrations.

- Show examples of different types of clutch discs and point out the parts of each.
- Discuss the materials used in clutch disc facings and caution the students against old clutch disc facings containing asbestos. Review Supplement 9, Unit 2, "Asbestos" if necessary.
- Explain the functions of a clutch disc.
- Manipulate the clutch disc to demonstrate how the torsional dampener springs decrease the initial jolt to the transmission input shaft when the clutch is first engaged.
- Review the boxed material on "Parts of a Clutch Disc."
- Discuss clutch disc variations, such as multiple clutch discs, rigid clutch discs, and situations where the specialist might find these variations; show examples if available.

Objective 8 Label three types of clutch linkages and match the names of their parts to illustrations.

- Use the vehicles in the shop to show examples of different types of clutch linkages.
- Point out how the linkages are attached to the chassis.
- Take examples of each type of linkage out of the vehicles to demonstrate how they transfer power from the clutch pedal to the release fork.
- Explain the functions of the clutch linkage.
- Review the boxed material on the "Self-Adjusting Cable Type Clutch."
- Show and discuss the slide/tape presentation, *Theory of Hydraulics*.
- Discuss the principle of hydraulic transfer of power and explain how hydraulic components can actually *increase* the power as well as transferring it.
- Review the boxed material on "Parts of a Clutch Master Cylinder," "Parts of a Clutch Slave Cylinder," and "Hydraulics—Using Liquids to Transmit Motion."

Objective 9 Label the parts involved in the clutch release mechanism on an illustration.

- Display actual examples of different types of release forks and pivots.
- Show how the release fork is attached to the pivot in each example.
- Show how the release fork is attached to the release bearing or release bearing collar in each example.
- Allow the students to handle the release bearing and point out the difference in this type of antifriction bearing and the bearings in the rear axle and differential.
- Review the boxed material on "Operation of the Clutch Release Mechanism."
- Pass around examples of worn and damaged release bearings and discuss the causes of such wear and damage.

APPLICATION

Objective 10 Diagnose clutch noise and performance problems. (Assignment Sheet 1)

- Show and discuss the video, *Spicer Clutch Operation.*
- Show and discuss the filmstrip, *The Automotive Clutch Assembly*, part 3, "Clutch Slippage, Gears Clash, and Driving Habits," and part 4, "Clutch Engagement and Disengagement, Noises, and Linkage Problems."
- Go over the introductory material in Assignment Sheet 1 and Supplement 1, "Clutch Troubleshooting Guide," and use Supplements 2, 3, & 4, "Clutch Performance Diagnosis Chart," "Clutch Noise Diagnosis Chart," and "Transmission Problems That Are Clutch-Related," to explain the possible causes of each type of problem.
- Stress the cost-effectiveness of first remedying clutch problems that can be solved without making a visual inspection of the clutch assembly components.
- Demonstrate how to perform the diagnostic tests required in Supplement 2.
- Have the students practice making these diagnostic tests.
- Use the applicable slides from the selection for *Noise, Vibration, and Harshness* and applicable material in the video, *NVH Vehicle Diagnosis*, to help teach clutch problem diagnosis.
- Have the students complete Assignment Sheet 1, using Supplements 1, 2, 3, & 4.

Objective 11A Inspect, adjust, and replace rod and lever type clutch linkage components. (Job Sheet 1)

- Show and discuss the video, *Spicer Clutch Installation.*
- Discuss Supplement 5, "Guidelines for Inspecting, Adjusting, and Replacing a Clutch Linkage."
- Explain clutch pedal free travel and show the students a vehicle which has incorrect clutch pedal free travel.
- Explain the boxed material, "Clutch Disc Wear Affects Clutch Pedal Free Travel."
- Demonstrate several different methods manufacturers suggest to measure clutch pedal free travel.

- While working inside the passenger compartment, use the opportunity to remind the students to cover the front seat to protect it while working inside the vehicle.

- Show the students how to inspect the parts of a rod and lever clutch linkage which are inside the passenger compartment.

- Display an example of an actual rod and lever type linkage that has worn and damaged parts.

- Use a vehicle on which the angle between the bellcrank and the transmission and the frame is incorrect to illustrate this common adjustment problem on a rod and lever type linkage.

- Demonstrate how to adjust the linkage on a rod and lever type clutch linkage.

- Have the students complete Job Sheet 1.

Objective 11B Inspect, adjust, and replace cable type clutch linkage components. (Job Sheet 2)

- Review the Introduction to Job Sheet 2, including the Special Guidelines for Cable Clutch Linkages.

- Display an example of an actual cable type linkage that has worn and damaged parts.

- Show the students an example of a clutch cable that is binding and demonstrate how to correct this condition.

- Demonstrate how to inspect the clutch cable for broken strands and explain how this can cause binding.

- Show the students how to inspect the parts of a self-adjusting cable linkage that are inside the passenger compartment.

- Demonstrate how to remove and replace the cable linkage.

- Have the students complete Job Sheet 2.

Objective 11C Inspect, adjust, repair, and replace hydraulic clutch components. (Job Sheet 3)

- Review the Introduction to Job Sheet 2, including the special guidelines for hydraulic type clutch linkages.

- Display actual examples of several types of hydraulic type linkages and demonstrate how they work.

- Show the students the type of brake fluid commonly used in hydraulic clutch linkages and discuss the safety guidelines for such fluid.

- Use the boxed material, "Bleeding the Hydraulic Clutch Linkage," to explain bleeding a clutch.

- Demonstrate how to bleed a hydraulic clutch linkage.

- Show the students how to adjust, remove, repair, and replace a hydraulic clutch linkage.

- Have the students complete Job Sheet 3.

Objective 11D Remove the transmission and clutch housing. (Job Sheet 4)

- Show and discuss the filmstrip, *The Automotive Clutch Assembly*, part 5, "How to Do a Clutch Job—the Disassembly."

- Use vehicles in the shop to show the students actual examples of the three types of clutch access. Point out the mountings used for each.

- Discuss with the students the usefulness of a clutch housing that has an inspection cover or hole.

- Show the students how to use a transmission jack.

- Demonstrate how to work with an assistant to remove the transmission and clutch housing.

- Have the students work in pairs to complete Job Sheet 4.

Objective 11E Remove, inspect, adjust, and replace the release bearing, release fork, and pivot. (Job Sheet 5)

- Show and discuss the filmstrip, *The Automotive Clutch Assembly*, part 6, "How to Do a Clutch Job—the Reassembly."

- Display actual examples of worn or damaged parts of the release bearing mechanism.

- Explain the cost-effectiveness of replacing the release bearing whenever the clutch assembly is disassembled.

- Encourage the students to test the new release bearings they install and not take for granted that they are free from flaws.

- Review Supplement 7, Unit 2, "Removing and Replacing Pressed-On Bearings," and demonstrate how to remove and replace the collar on a release bearing.

- Demonstrate the procedures in Job Sheet 5, giving special attention to the amount of lubrication to use.

- Show the students how to adjust the positions of the various components in the release bearing mechanism.

- Have the students complete Job Sheet 5.

Objective 11F Remove, inspect, and replace the pressure plate assembly and clutch disc. (Job Sheet 6)

- Explain *riding the clutch*.

- Discuss the fact that clutch facings are expected to wear as the clutch is used but point out the types of poor driving habits and clutch problems that can cause excessive wear of clutch disc facings.

- Display examples of actual worn and damaged clutch discs and pressure plate assemblies and using Supplement 2, "Clutch Performance Diagnosis Chart," point out the various types of possible damage and their causes.

- Review Supplement 9, Unit 2, "Asbestos," and discuss handling this material in clutch disc facings.

- Show how to vacuum and remove asbestos when servicing a clutch disc which has asbestos facings.

- Have the students check the service manuals available in the classroom to see how many of them recommend that the pressure plate assembly be replaced whenever the clutch disc is replaced.

- Demonstrate the procedures in Job Sheet 6.

- Stress the special hardened nature of the pressure plate mounting bolts and point out that ordinary bolts cannot be used as replacements.

- Have the students work in pairs to complete Job Sheet 6.

Objective 11G Remove, inspect, and replace the pilot bushing or bearing. (Job Sheet 7)

- Emphasize that the pilot bushing/bearing is installed in the crankshaft bore rather than in the flywheel—a common misconception.
- Display actual examples of various types of pilot bushings and bearings.
- Show examples of worn and damaged bushings and bearings.
- Explain the cost-effectiveness of replacing the pilot bushing or bearing whenever the clutch assembly is disassembled.
- Demonstrate the procedures in Job Sheet 7.
- Have the students complete Job Sheet 7.

Objective 11H Inspect, remove, repair, service, and replace the flywheel and ring gear. (Job Sheet 8)

- Show the students actual examples of damaged and worn flywheels.
- Discuss the fact that the flywheel is a component that can often be *repaired* rather than *replaced* and have the students make a list of the types of flywheel damage that can be repaired.
- Discuss the special qualifications needed by the machinists and clutch specialists that repair flywheels.
- Mention where such specialists can be located in your community.
- Show the students how to use a flywheel turner.
- Demonstrate the procedures in Job Sheet 8.
- Stress the special hardened nature of the flywheel mounting bolts and point out that ordinary bolts cannot be used as replacements.
- Have the students work in pairs to complete Job Sheet 8.

Objective 11I Measure crankshaft end play and flywheel runout. (Job Sheet 9)

- Show the students an example of a flywheel with excessive runout and a vehicle that has crankshaft end play.
- Discuss the procedures that are necessary to eliminate crankshaft end play and the importance of having a specialist trained in this area carry out this task.
- Review the procedures in Supplement 8, Unit 1, "Using a Dial Indicator," if necessary.
- Demonstrate the procedures in this Job Sheet.
- Point out to the students where to press on the front of the engine pulley in order to measure crankshaft end play.
- Have the students work in pairs to complete Job Sheet 9.

Objective 11J Inspect the engine block, clutch housing, and transmission housing mating surfaces. (Job Sheet 10)

- Have the students use Supplements 2, 3, and 4 to make a list of clutch problems that can be caused by the misalignment of the clutch housing.
- Demonstrate the procedures in Job Sheet 10.
- Have the students complete Job Sheet 10.

Objective 11K Measure clutch housing face runout and clutch housing bore runout. (Job Sheet 11)

- Discuss the advantages and disadvantages offered by an integrated housing for the clutch and transmission.
- Demonstrate the procedures in Job Sheet 11.
- Have the students work in pairs to complete Job Sheet 11.

Objective 11L Replace the clutch housing and transmission. (Job Sheet 12)

- Explain why clutch alignment pins are used to reinstall the transmission to the clutch housing.
- Discuss the importance during the replacement procedure of avoiding any damage to clutch parts that have been repaired or replaced.

- Demonstrate the procedures in Job Sheet 12.
- Have the students complete Job Sheet 12.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate class members on assignment sheet activities if not previously done. Provide them with copies of Supplement 1, "Clutch Troubleshooting Guide," Supplement 2, "Clutch Performance Diagnosis Chart," Supplement 3, "Clutch Noise Diagnosis Chart," and Supplement 4, "Transmission Problems That Are Clutch-Related."
- Give the practical tests. Evaluate the tests on forms provided.
- Reteach and retest as required
- Complete the appropriate section of the competency profiles.
- Review individual and group performance in order to evaluate teaching methods.
- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- Abbott, Sheldon L. *Automotive Power Trains*, 2nd ed. Encino, California: Glencoe Publishing Co., 1988.
- *Car 1987 Shop Manual—Powertrain, Lubrication, Maintenance*. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.
- *Chilton's Auto Repair Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- *Chilton's Import Car Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
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Media

> Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Automotive Clutch Assembly, The.* 6 filmstrips, 9-14 minutes each. Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565. Basic Parts and their Operation; Power Flow; Clutch Slippage, Gears Clash, and Driving Habits; Clutch Engagement and Disengagement, Noises, and Linkage Problems; How to Do a Clutch Job—the Disassembly; How to Do a Clutch Job—the Reassembly.
- *Automotive Information Council—Reference Center.* 13505 Dulles Technology Drive, Herndon, Virginia 22071-3415, phone (703) 904-0700. The AIC Reference Center has a reference base of over 10,000 volumes, maintaining subscriptions to over 100 trade and consumer publications relating to the automotive industry. Their computer indexing system can provide educators with up-to-date print-outs of books, articles from periodicals, statistical abstracts, press releases, catalogues, and other reference materials on 90 automotive subject classifications. AIC's services are free of charge. Copies of current articles from periodicals are also available free if requested in nominal quantities.
- *Noise, Vibration and Harshness.* 50 color slides, 58 p. Instructor Guide, and 46 p. Student Text. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. The object of this text is to improve mechanical skills, to increase the accuracy of diagnosis, and to provide time saving procedures for the identification and elimination of problems relating to vehicle noise, vibration and harshness.

- *NVH Vehicle Diagnosis*. 26 minutes, color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Defines noise, vibration, and harshness concerns; provides diagnostic theory and repair procedures in step-by-step format.

- *Spicer Clutch Installation*. 30 minutes, video. Dana Corporation, School Assistance Department, P.O. Box 453, Toledo, Ohio 43692-0453, phone 1-419-535-4300. Teaches how to avoid some expensive mistakes or needless downtime. Covers the initial clutch adjustment for the self-adjuster type clutch.

- *Spicer Clutch Operation*. 15 minutes, video. Dana Corporation, School Assistance Department, P.O. Box 453, Toledo, Ohio 43692-0453, phone 1-419-535-4300. Drivers and mechanics need to understand the reasons good operating techniques are important to clutch life.

- *Theory of Hydraulics*. 15 minutes, slides and tape. Dana Corporation, School Assistance Department, P.O. Box 453, Toledo, Ohio 43692-0453, phone 1-419-535-4300. Explains basic hydraulic theory. The concepts of flow, pressure, and force are discussed as are the components necessary to build a simple hydraulic system.

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions:

Objective	Question
1	1, 2
2	3
3	4
4	5
5	6
6	7
7	8
8	9
9	10
10	11, 12
11A	13
11B	14
11C	15
11D	16
11E	17
11F	18
11G	19
11H	20
11I	21
11J	22
11K	23
11L	24

ANSWER KEY

1.	A	13.	A
2.	C	14.	B
3.	B	15.	D
4.	C	16.	D
5.	C	17.	B
6.	D	18.	D
7.	A	19.	B
8.	A	20.	C
9.	D	21.	A
10.	C	22.	C
11.	B	23.	B
12.	D	24.	D

PRETEST

SERVICE CLUTCHES

III

NAME ______________________ SCORE ______

DIRECTIONS

Read the following questions and problems. Then put the letter of the item that best answers the question or solves the problem in the blank.

______1. A type of clutch problem in which a shuddering vibration is felt throughout the vehicle when the clutch disc is first contacted by the pressure plate is:

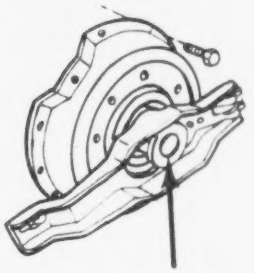
A. Clutch chatter
B. Clutch vibration
C. Clutch slippage
D. Clutch drag

______2. If you "adjust the clutch," you are:

A. Adjusting how tight the flywheel and pressure plate hold the clutch disc when the clutch is engaged
B. Tightening the clutch linkage
C. Adjusting the distance the clutch pedal moves before the release bearing contacts the pressure plate assembly
D. Adjusting how far down you must push the clutch pedal to engage the clutch

______3. The part of the clutch indicated by the arrow is the:

A. Release fork
B. Release bearing
C. Pilot bearing
D. Clutch disc hub



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______4. The clutch component that transfers pressure from the clutch linkage to the pressure plate assembly to disengage the clutch is the:

A. Clutch cable
B. Clutch disc
C. Release bearing assembly
D. Transmission input shaft

______5. Technician A says that when the clutch is engaged the flywheel and pressure plate assembly are turning. Technician B says that the flywheel and pressure plate assembly are turning when the clutch is disengaged. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

______6. The flywheel is bolted to the:

A. Clutch disc
B. Pressure plate
C. Pilot bushing
D. Crankshaft

______7. What type of clutch disc is most commonly used in new passenger cars?

A. Diaphragm spring type
B. Coil spring type
C. Lever type
D. Semi-centrifugal type

______8. What part of the clutch disc touches the flywheel and pressure plate assembly when the clutch is engaged?

A. Facings
B. Side plates
C. Hub flange
D. Stop cushions

______9. Which type(s) of clutch linkage can be self-adjusting?

A. Rod and lever
B. Cable
C. Hydraulic
D. Both B and C

______10. When the clutch pedal is depressed, the release bearing is pushed against the:

A. Release fork
B. Pressure plate
C. Pressure plate assembly
D. Clutch disc

______11. When diagnosing clutch problems, Technician A says that you should always inspect the parts of the clutch first. Technician B says that inspection should be the last step in diagnosis. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

______12. If oil has leaked into the clutch housing, the proper corrective action is to fix the leak and:

A. Clean the clutch disc with an approved cleaning solvent
B. Adjust the clutch pedal free travel
C. Replace the pilot bushing
D. Replace the clutch disc

______13. In a rod and lever type clutch linkage, clutch pedal free travel can be affected by:

A. Worn linkage pivots
B. Worn linkage cable
C. Worn rod in the master cylinder
D. All of the above

______14. A ***pawl*** is a part of the clutch linkage in a:

A. Rod and lever type linkage
B. Self-adjusting cable type linkage
C. Hydraulic linkage
D. Both B and C

_____15. What is the most common type of clutch linkage in modern automobiles?

A. Rod and lever
B. Cable
C. Self-adjusting cable
D. Hydraulic

_____16. Which of the following components must be removed in order to replace the clutch disc in a front-engine, rear-wheel drive vehicle?

A. Clutch housing
B. Transmission
C. Driveline
D. All of the above

_____17. The function of a return spring is to:

A. Pull the pressure plate away from the clutch disc when the clutch is disengaged
B. Pull the release fork away from the pressure plate assembly when the clutch is engaged
C. Assist the driver to push down the clutch pedal
D. Absorb some of the force on the clutch disc when the clutch is first engaged

_____18. What other component(s) is(are) often replaced when the clutch disc is replaced?

A. Pressure plate assembly
B. Pilot bearing
C. Release bearing
D. All of the above

_____19. Where is the pilot bushing installed?

A. In the flywheel
B. In the crankshaft bore
C. Attached to the release bearing
D. In the clutch linkage

_____20. Which type of flywheel damage can be repaired?

A. Cracks
B. Deep grooves
C. Excessive runout
D. Heat damage

_____21. What clutch problem is most likely to be caused by excessive crankshaft end play?

A. Clutch slippage
B. Binding in the clutch linkage
C. Worn release bearing
D. Poor clutch housing alignment

_____22. Which problem is **not** one that can be caused by poor engine—clutch housing—transmission alignment?

A. Transmission jumping out of gear
B. Excessive spin-down time
C. Oil in the clutch assembly
D. Rough clutch pedal action

_____23. In the test for clutch housing bore runout, the clutch alignment tool must be firmly fixed to the:

A. Clutch disc
B. Pilot bushing or bearing
C. Flywheel bore
D. Pressure plate assembly

_____24. Alignment pins are used to:

A. Align the clutch linkage to disengage the clutch
B. Align the pressure plate assembly to the flywheel
C. Adjust the levers on the pressure plate assembly
D. Install the transmission housing to the clutch housing

INFORMATION SHEET

SERVICE CLUTCHES *III*

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive clutch by selecting the correct definition from four choices.

adjusting the clutch — The process of adjusting the distance the clutch pedal moves before the release bearing contacts the pressure plate assembly

alignment — The proper position of parts or components in relation to each other

bell-mouthing — In a clutch, a pattern of wear in which the splines on the hub of a clutch disc are more worn *away* from the axis than they are *near* the axis

binding — A condition in which a part or parts are stuck or otherwise kept from moving in their normal way

bleeding the clutch — Removing air from the hydraulic system in a hydraulic clutch linkage

bushing — A cylindrical metal lining designed to promote the smooth movement of an adjoining rotating part

centrifugal force — A force that pushes an object or parts of an object outward from the center of rotation

clutch chatter — A type of clutch problem in which a shuddering vibration is felt throughout the vehicle when the clutch disc is first contacted by the pressure plate

clutch drag — A type of clutch problem in which the clutch disc does not come to a complete stop within the amount of time specified by the vehicle's manufacturer after the clutch is disengaged

clutch pedal free travel — The distance the clutch pedal moves before the release bearing contacts the pressure plate assembly

clutch slippage — A type of clutch problem in which the clutch disc is not clamped firmly between the pressure plate and the flywheel when the clutch is engaged

compress — To press or squeeze together

dampen — To reduce the activity of something

diaphragm — A thin flexible disc

disengaged — In a clutch, when the clutch *is not* transmitting the engine's turning power from the engine to the transmission

engaged — In a clutch, when the clutch *is* transmitting the engine's turning power from the engine to the transmission

hydraulic — Operated by fluid under pressure

inertia — A property of matter in which an object at rest tends to remain at rest, and an object in motion tends to remain in motion, unless either object is acted upon by an outside force

integral — Formed as a unit with another part

linkage — Parts that connect one assembly or part to another

pivot — A shaft or pin on which something turns

porous — Containing tiny openings into which liquid may pass

resistant — Opposing

retract — To draw back

riding the clutch — When the driver allows his foot to remain on the clutch pedal when not disengaging the clutch

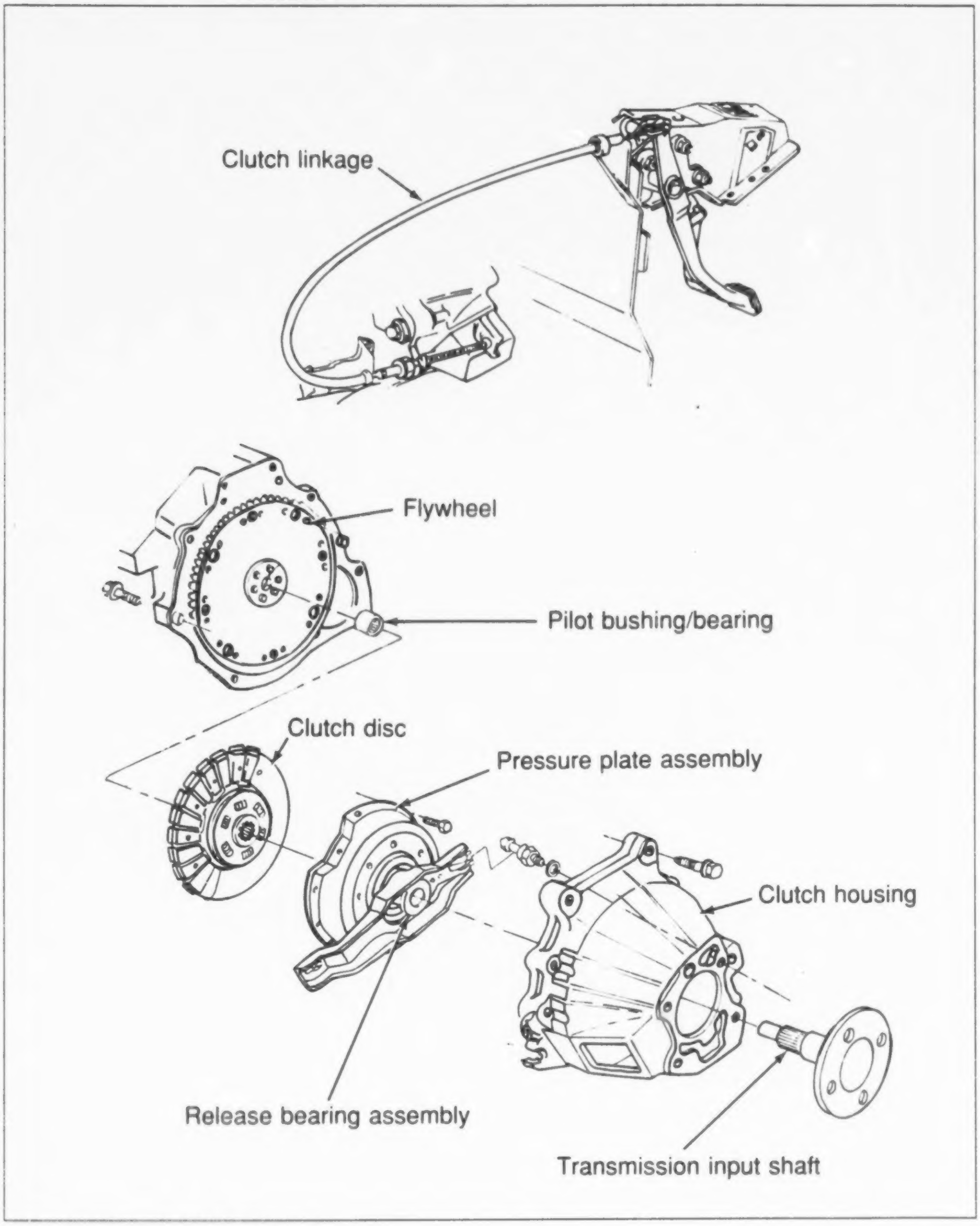
shrink fit — A method of fitting two parts tightly together without fasteners. The outer part is heated and the inner part is cooled before joining

spin-down time — In a clutch, the amount of time it takes for the clutch disc to stop spinning when the clutch is disengaged

torsional — The twisting of one part around another

OBJECTIVE 2 **Label the major components of the clutch system on an illustration.**

FIGURE 1


Clutch linkage
Flywheel
Pilot bushing/bearing
Clutch disc
Pressure plate assembly
Clutch housing
Release bearing assembly
Transmission input shaft

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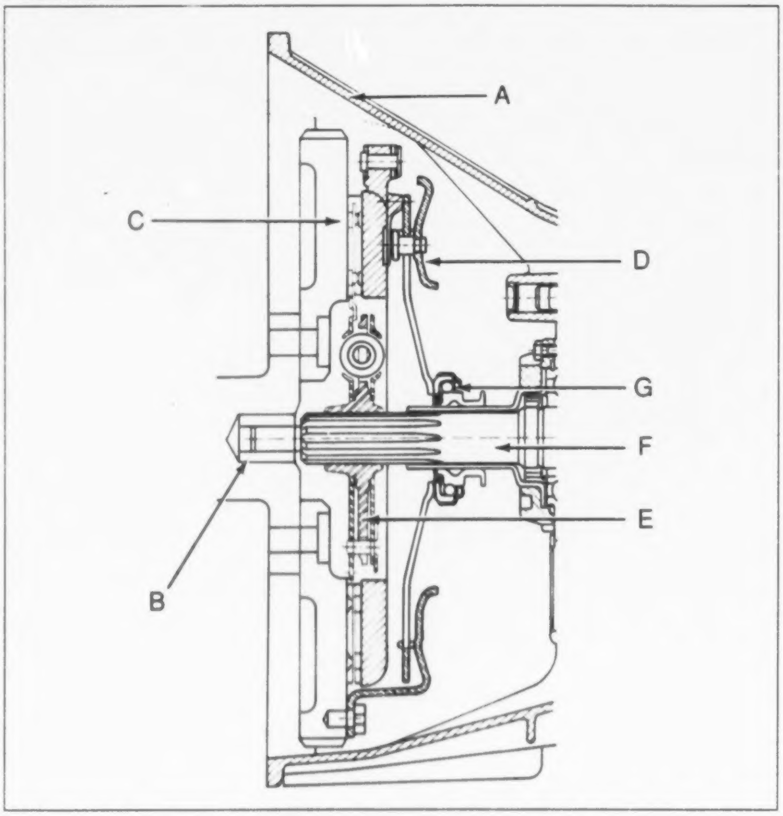
OBJECTIVE 3

Match the names of clutch components to phrases describing the components or giving their functions.

FIGURE 2



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A. **Clutch Housing** — Sometimes called the ***bell housing***, the clutch housing is an aluminum or cast iron container bolted to the engine block on one side and either bolted to, or an integral part of, the transmission on the other.

Its function is to:

- Protect the starter and clutch components (except the clutch linkage) from dirt, water, and heat build-up,
- Support the transmission, starter, and parts of the clutch linkage, and
- Align the engine with the transmission.

NOTE: Some clutch housings have inspection holes or covers which allow the clutch assembly to be inspected without removing the entire clutch housing.

B. **Pilot Bushing/Bearing** — The pilot bushing is a sleeve made of porous bronze impregnated with oil which is press fit into the socket of the engine crankshaft. A ball bearing or a needle bearing is sometimes used in place of a bushing.

Its function is to:

- Support the front part of the transmission input shaft,
- Align the transmission input shaft to the crankshaft, and
- Allow the socket of the crankshaft to rotate freely around the transmission input shaft when the clutch is disengaged.

C. **Flywheel** — The flywheel is a large, heavy, machined disc made of iron or aluminum faced with iron which is bolted to the engine crankshaft.

Its function is to:

- Provide a mounting for the flywheel ring gear (which, when turned by the vehicle's starting system, starts the engine),
- Smooth out the vibrations caused by the engine firing pulses,
- Provide rotating inertia which carries the engine parts over the non-power parts of their strokes,
- Provide a place to mount the pressure plate assembly, and
- Supply the clutch with its driving force.

D. **Pressure Plate Assembly** — The metal pressure plate assembly is bolted to the flywheel, surrounding the clutch disc. Although the pressure plate assembly has a number of parts, it is sometimes called the ***pressure plate*** or ***cover assembly***.

Its function is to:

- Clamp the clutch disc tightly against the flywheel when the clutch is engaged, and
- Respond to pressure from the release bearing to release the clutch disc and disengage the clutch.

E. **Clutch Disc** — The clutch disc is a disc-shaped assembly made of high quality steel faced with friction material, which is splined to the transmission input shaft in a position between the flywheel and the pressure plate in the pressure plate assembly. A clutch disc is sometimes called a ***friction disc***, ***driven plate***, or ***clutch plate***.

Its function is to:

- Transfer torque from the rotating flywheel and pressure plate to the transmission input shaft, and
- Cushion the initial jolt of power as engine torque is transferred to the transmission gears.

NOTE: Heavy-duty trucks and racing vehicles sometimes use more than one clutch disc.

F. **Transmission Input Shaft** — The transmission input shaft, made of high quality steel, is the shaft of the transmission's main drive gear. Sometimes called the ***clutch shaft***, the shaft part of this gear extends into the clutch housing, through the pressure plate assembly and the clutch disc, and is supported on the other end by the pilot bushing/bearing.

Its function is to transfer engine torque from the clutch disc to the transmission.

G. **Release Bearing Assembly** — The release bearing assembly consists of a *sealed bearing* press fit to a *collar*. The release bearing assembly surrounds the transmission input shaft's bearing retainer in a position between the release fork and the pressure plate assembly. The release bearing is sometimes called a ***throwout bearing***.

Its function is to transfer pressure from the clutch linkage to the pressure plate assembly to disengage the clutch.

H. **Clutch Linkage** (not shown) — The clutch linkage is a series of mechanical and/or hydraulic parts which begins with the clutch pedal and ends with the release fork.

Its function is to transfer the pressure of the driver's foot on the clutch pedal into pressure on the release bearing assembly.

OBJECTIVE 4

Identify the operating condition of the major clutch components in both the engaged and the disengaged positions.

CLUTCH OPERATION

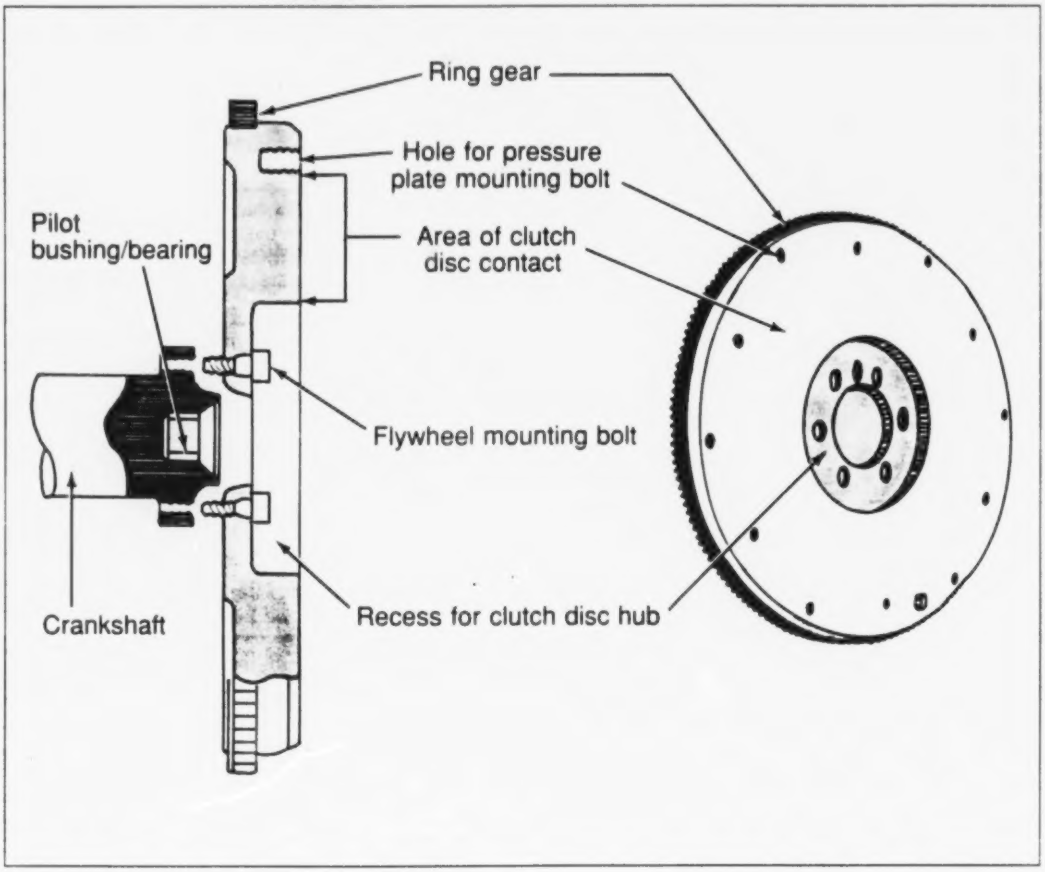
	ENGAGED	DISENGAGED
Clutch Linkage	Driver's foot is not on the clutch pedal.	Driver's foot is pressing down on the clutch pedal.
Release Bearing Assembly	The release bearing is not rotating or touching the pressure plate assembly.	The release fork has pushed the release bearing against the pressure plate spring/levers. The release bearing rotates with the pressure plate assembly when it presses down the spring.
Pressure Plate Assembly	The pressure plate assembly is rotating and the pressure plate springs have forced the pressure plate against the clutch disc, clamping it firmly against the rotating flywheel.	The pressure plate assembly is rotating, but the pressure of the release bearing on the pressure plate spring/levers has forced the pressure plate away from the clutch disc, releasing it from the flywheel.
Clutch Disc	The clutch disc is rotating, clamped tightly between the rotating pressure plate and the flywheel.	The clutch disc is not in contact with the rotating pressure plate or the flywheel. If the clutch disc is still rotating, it does so because the transmission shaft has not yet slowed down.
Transmission Input Shaft	The rotating clutch disc is turning the transmission input shaft.	The clutch disc is not turning the transmission input shaft, but the left-over movement (inertia) in the transmission may be turning it.
Flywheel	Rotating with the engine crankshaft, the flywheel is turning the pressure plate assembly and the clutch disc.	Rotating with the engine crankshaft, the flywheel is turning the pressure plate assembly but not the clutch disc.

Clutch Spin Time

Clutch spin time is the amount of time it takes for the transmission input shaft and the clutch disc to stop spinning when the clutch disengages. If there is excessive clutch spin time, transmission gears can be damaged during shifting. Excessive clutch spin time can be caused by poor clutch housing to transmission alignment and by a dry or worn pilot bushing/bearing.

OBJECTIVE 5 **Match the names of the parts of a flywheel to an illustration.**

FIGURE 3

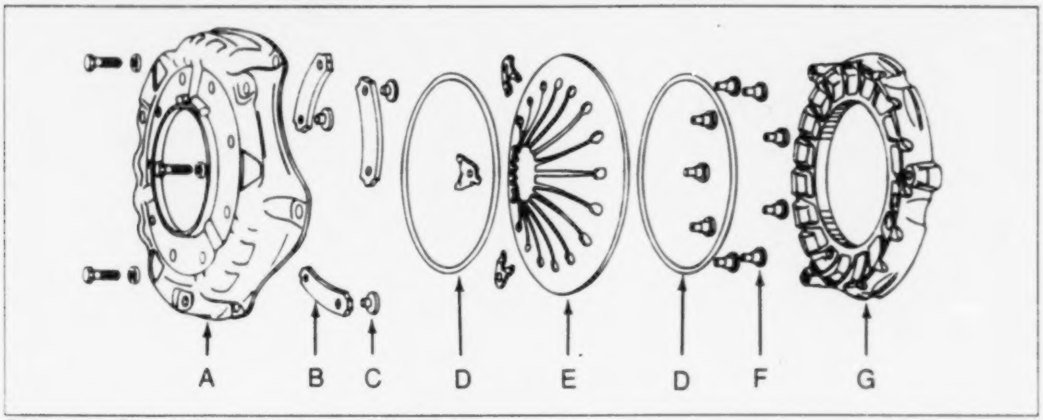

Ring gear
Hole for pressure plate mounting bolt
Pilot bushing/bearing
Area of clutch disc contact
Flywheel mounting bolt
Crankshaft
Recess for clutch disc hub

NOTE: In addition to being bolted to the flywheel by mounting bolts, some pressure plate assemblies are also held in place by solid or hollow metal *dowels* which are fit into corresponding holes in the flywheel and the pressure plate cover. The ring gear is a separate part which is ***shrink fit*** onto the circumference of the flywheel. (In a shrink fit, the part that fits on the outside is heated to expand it and then is placed around the inside part, which is sometimes cooled. As the outside part cools, it *shrinks*, forming an extremely tight fit between the two parts.)

OBJECTIVE 6 **Label three types of pressure plate assemblies and match the names of their parts to illustrations.**

DIAPHRAGM SPRING TYPE (Figures 4 & 5)

FIGURE 4



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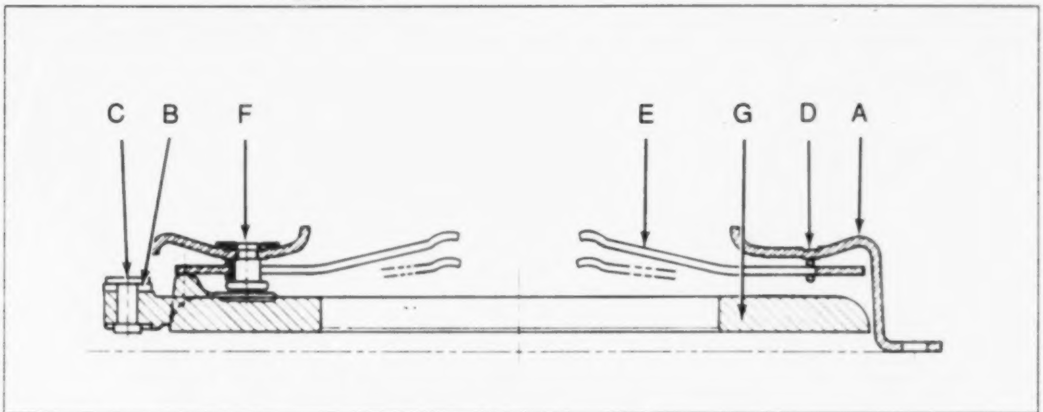
A.	Pressure plate cover	E.	Diaphragm spring
B.	Drive strap	F.	Spring pivot rivet
C.	Drive strap rivet	G.	Pressure plate
D.	Gasket		

FIGURE 5



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NOTE: In a ***diaphragm spring type*** pressure plate assembly, the design of the diaphragm spring keeps the pressure plate clamped tightly against the clutch disc and flywheel. Only when the release bearing presses on the center of the diaphragm spring, does it release its hold, disengaging the clutch disc. The diaphragm spring type pressure plate assembly is the most common type.

LEVER TYPE (Figures 6 & 7)

FIGURE 6

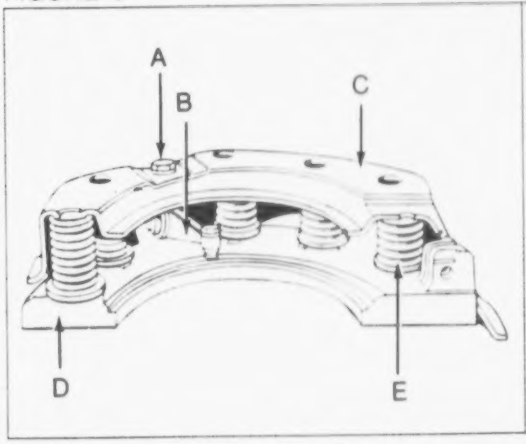

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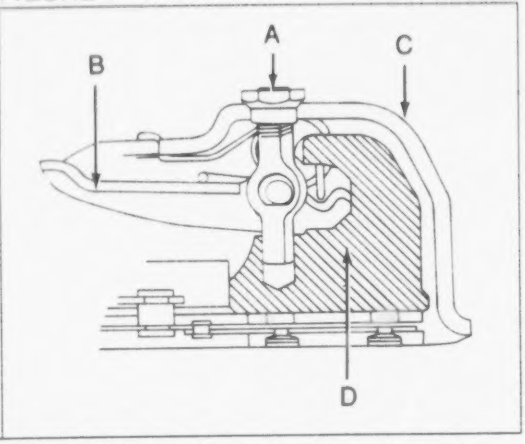
FIGURE 7



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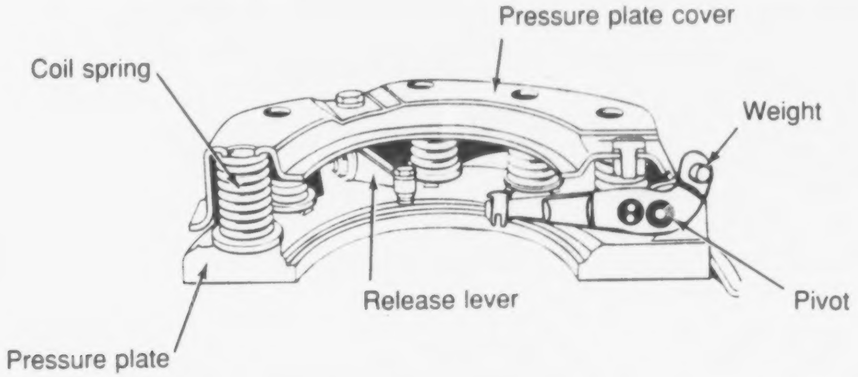
A. Lever adjusting nut
B. Release lever
C. Pressure plate cover
D. Pressure plate
E. Coil Spring

NOTE: In a ***lever type*** pressure plate assembly, coil springs clamp the pressure plate tightly against the clutch disc and flywheel. When the release bearing presses on the levers, the release levers lift the pressure plate away from the flywheel, disengaging the clutch disc. The height of some lever type pressure plate assemblies can be adjusted. A clutch using a lever type pressure plate assembly is also sometimes called a ***coil spring clutch*** or a ***Borg and Beck clutch***.

SEMI-CENTRIFUGAL TYPE (Figure 8)

FIGURE 8



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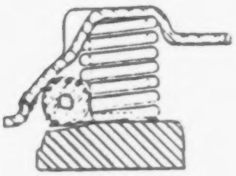
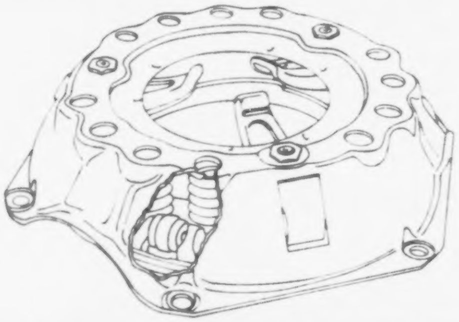
NOTE: A ***semi-centrifugal type*** pressure plate assembly operates in basically the same way as a lever type assembly, except that there are *weights* on the outside ends of the levers. As the pressure plate assembly rotates with the flywheel, centrifugal force acts on these rotating weights, aiding the coil springs to clamp the pressure plate even tighter against the clutch disc. The faster the flywheel rotates, the more pressure the weights exert. Because of this additional help, the coil springs in a semi-centrifugal type pressure plate assembly don't have to be as strong and the driver does not have to press the clutch pedal as hard to disengage the clutch. Semi-centrifugal pressure plate assemblies are used on large trucks.

ROLLER TYPE SEMI-CENTRIFUGAL PRESSURE PLATE ASSEMBLY





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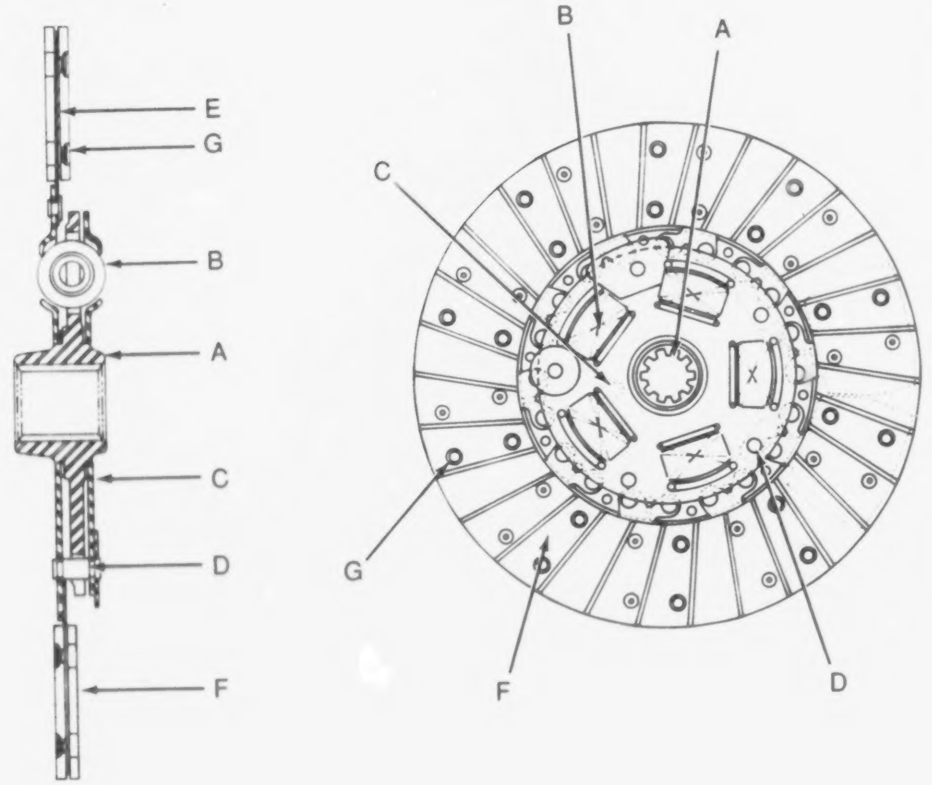
Some semi-centrifugal pressure plate assemblies use rollers between the pressure plate and the pressure plate cover. As the clutch rotates, centrifugal force wedges the rollers between the pressure plate cover and the pressure plate, aiding the coil springs to clamp the pressure plate against the clutch disc.

OBJECTIVE 7 **Match the names of the parts of a clutch disc to illustrations.**

FIGURE 9



A. Hub and Hub Flange

B. Torsional Dampener Springs

C. Side Plates

D. Stop Pins

E. Cushion Springs

F. Facings

G. Rivets

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PARTS OF A CLUTCH DISC

A. **Hub and Hub Flange** — The hub and its flange are a single part made of high quality steel which forms the base of the clutch disc. The hub is splined to fit on the transmission input shaft so that when the clutch disc rotates it turns the transmission input shaft. The splines also allow the clutch disc to move back and forth slightly on the input shaft as the pressure plate clamps the clutch disc against the flywheel when the clutch is engaged and releases it when it is disengaged.

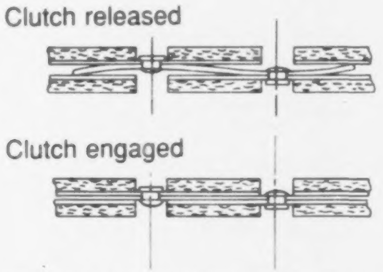
B. **Torsional Dampener Springs** — Torsional dampener springs are coil springs that act as built-in shock absorbers. They allow the clutch disc to twist slightly when the clutch is first engaged, keeping power surges from being transmitted to the transmission. Torsional dampener springs are also sometimes called ***damper springs*** or ***torsional coil springs***.

NOTE: Clutch discs that do not have torsional dampener springs are called ***rigid*** clutch discs. Rigid clutch discs are used on race cars where the need for fast starts and quick gear changes make the action of the normal ***flexible*** clutch disc undesirable.

C. **Side Plates** — Two stamped steel side plates are installed on the either side of the hub flange to contain the torsional dampener springs and the center portion of the assembly. The cushion springs are riveted to the inside edge of one these side plates.

D. **Stop Pins** — Stop pins hold the two side plates together while permitting them to rotate slightly on the hub flange as the clutch disc assembly twists when the clutch is first engaged. The stop pins keep the side plates from being compressed against the hub flange as well as limiting the distance the side plates can twist on the flange.

E. **Cushion Springs** — The cushion spring, which is riveted to a side plate, has two common forms. It can be in the form of a very thin, wave-like disc, or it can be made up of individual wafer-like segments, each of which are slightly curved. Made of stamped spring steel, the curved nature of the cushion spring encourages the clutch disc to compress gradually, resulting in a smoother clutch engagement. Cushion springs are also called ***wave springs***, ***facing springs***, or ***marcels***.



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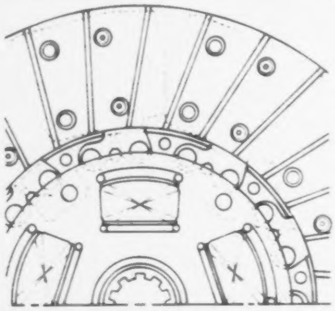

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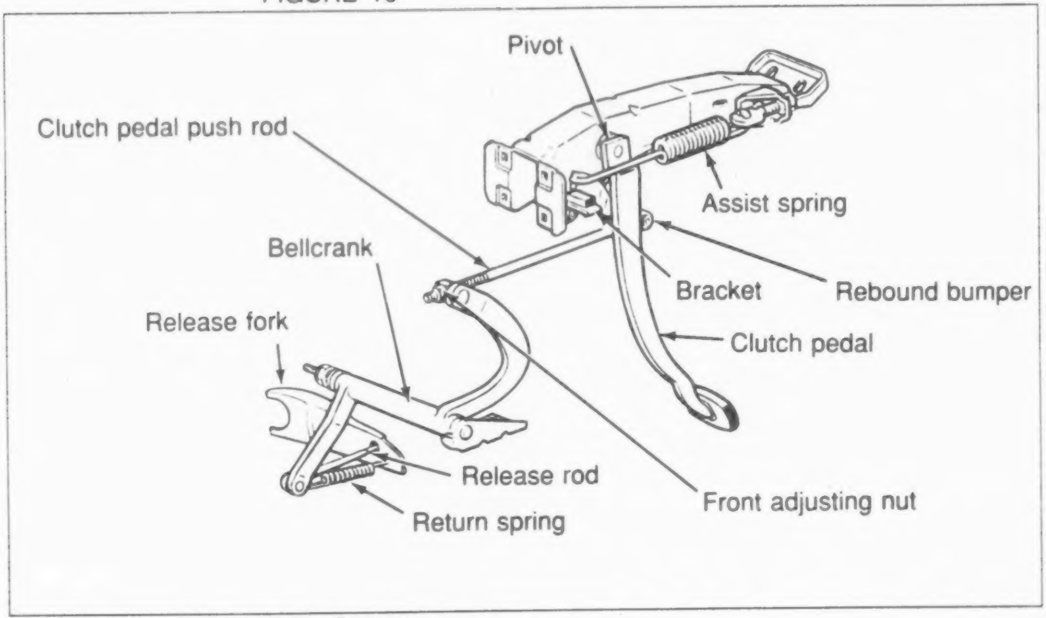
F. **Facings** — Facings are heat-resistant material bonded or riveted with brass **rivets** to both sides of the cushion springs in order to prevent the clutch plate from slipping when it is clamped between the flywheel and the pressure plate. ***Grooves*** in the facing (1) assist in getting rid of dust which forms as the facings wear, (2) help the facing avoid heat build-up, and (3) keep a vacuum from forming between the clutch disc, flywheel and pressure plate.

In the past, most friction discs were made of asbestos and cotton materials pressed or woven with resins and/or copper wire. Because of the health hazards of asbestos (Supplement 9, Unit 2), newer clutch disc facings are made from other materials such as ceramic and metal. It is normal for facings to be gradually worn away as the clutch is engaged and disengaged.

OBJECTIVE 8 **Label three types of clutch linkages and match the names of their parts to illustrations.**

ROD AND LEVER TYPE

FIGURE 10


Pivot
Clutch pedal push rod
Assist spring
Bellcrank
Bracket
Rebound bumper
Release fork
Clutch pedal
Release rod
Front adjusting nut
Return spring

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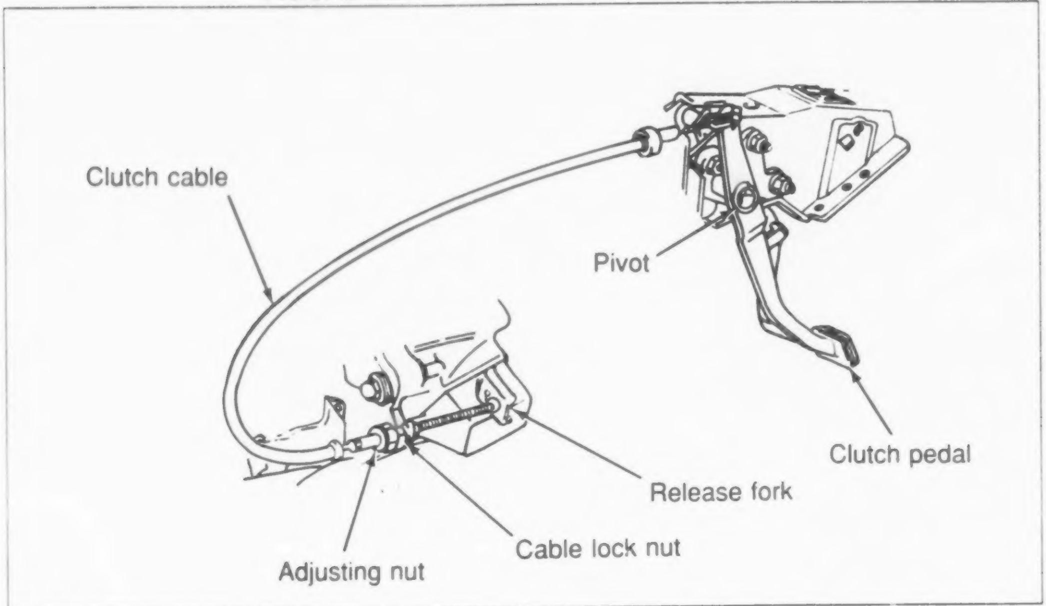
NOTE: A ***rod and lever*** type clutch linkage is a mechanical linkage which connects the clutch pedal to the release fork through a series of rods and levers. Using a number of pivot points which require lubrication and are subject to wear, this type of linkage is comparatively heavy and takes up more space than the other types. Rod and lever linkages are extremely dependent upon the correct frame alignment and any deviation can cause binding and loss of proper clutch pedal free travel.

CABLE TYPE

FIGURE 11


Clutch cable
Pivot
Clutch pedal
Release fork
Cable lock nut
Adjusting nut

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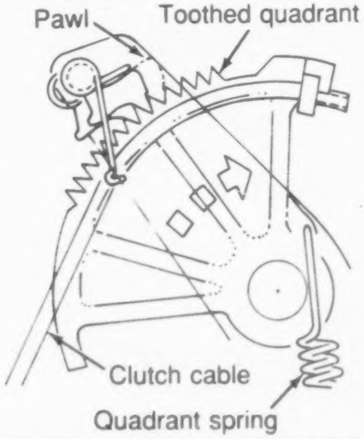
NOTE: The mechanical ***cable*** type clutch linkage is the simplest type of linkage and is both inexpensive and space-saving. Pressing the clutch pedal causes the metal cable to pull the release fork against the release bearing. However, the metal cable can break during extremes of temperature and will gradually stretch after use, increasing clutch free travel.


Pawl
Toothed quadrant
Clutch cable
Quadrant spring

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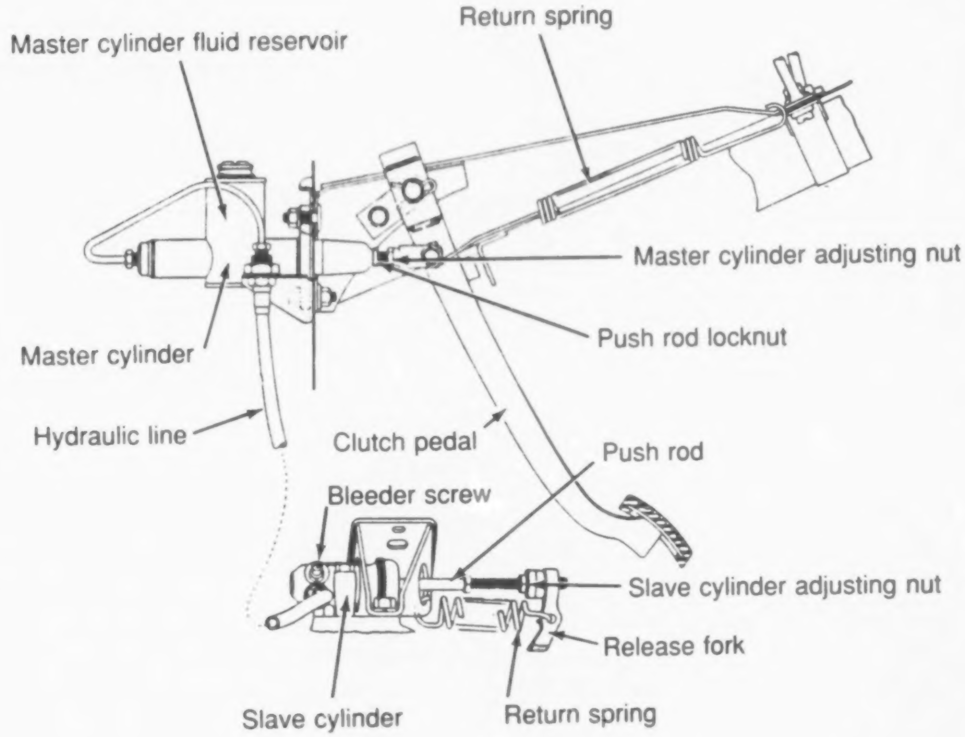
SELF-ADJUSTING CABLE TYPE CLUTCH

Most newer cable linkages are ***self-adjusting***. The clutch cable is threaded through the outer edge of a toothed *quadrant*, a device shaped like one-fourth of a circle. A slight tension is kept on the quadrant by a *quadrant spring*. When the clutch pedal is depressed, the cable is pulled through the quadrant, pulling the release fork against the release bearing. When the pedal is released, the *pawl* engages one of the teeth on the quadrant, automatically taking up any slack in the clutch cable.

HYDRAULIC

FIGURE 12


Return spring
Master cylinder fluid reservoir
Master cylinder adjusting nut
Push rod locknut
Master cylinder
Hydraulic line
Clutch pedal
Push rod
Bleeder screw
Slave cylinder adjusting nut
Release fork
Slave cylinder
Return spring

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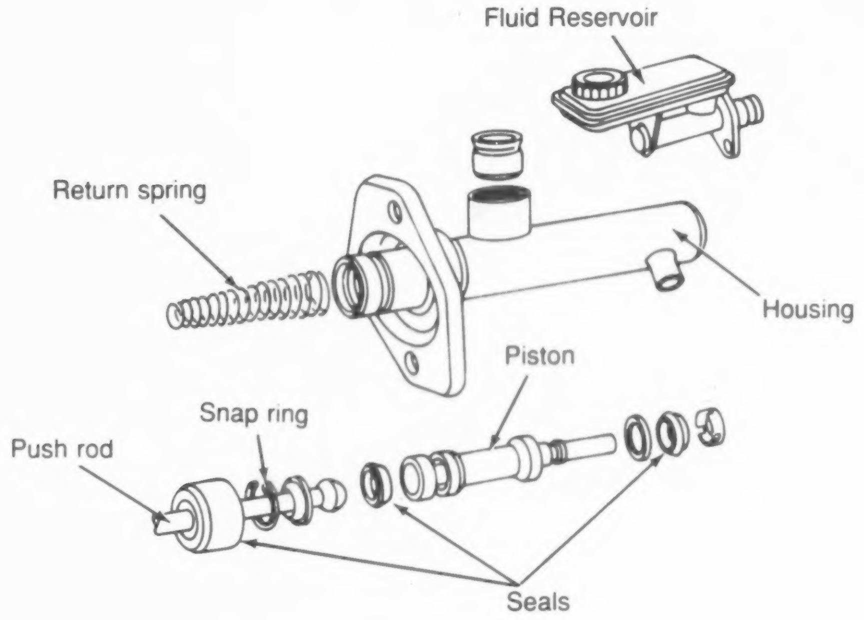
NOTE: A ***hydraulic*** clutch linkage uses hydraulic power to transfer the pressure on the clutch pedal to the release fork. Because a hydraulic clutch linkage takes up little space, they are popular on small vehicles. And because little pressure is needed to compress the clutch pedal, they are also popular for heavy-duty applications. Although some hydraulic clutch linkages are adjustable, most are not. Hydraulic linkages are the most common type of clutch linkage.

PARTS OF A CLUTCH MASTER CYLINDER


Fluid Reservoir
Return spring
Housing
Piston
Snap ring
Push rod
Seals

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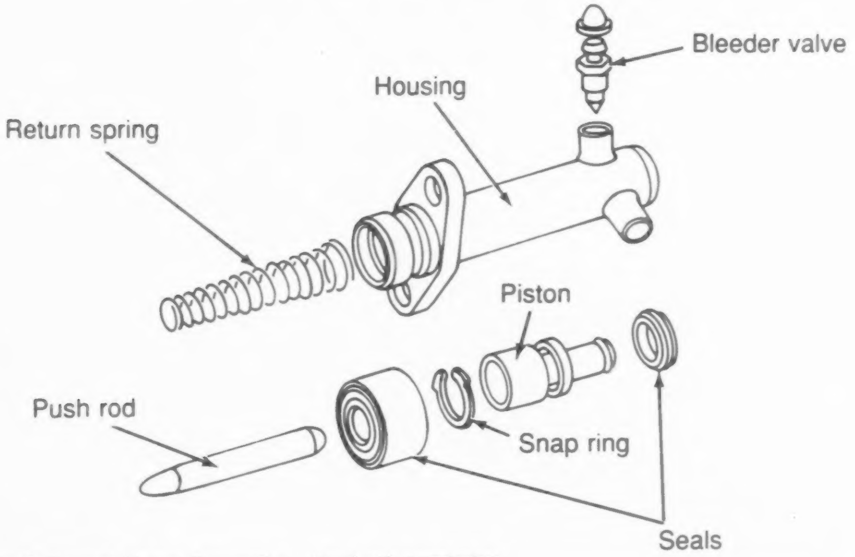
PARTS OF A CLUTCH SLAVE CYLINDER


Bleeder valve
Housing
Return spring
Piston
Push rod
Snap ring
Seals

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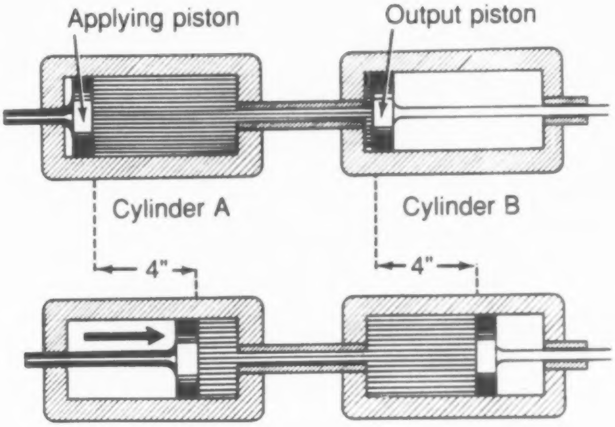
HYDRAULICS — USING LIQUIDS TO TRANSMIT MOTION

Because liquids resist being compressed, liquids under pressure react as though they were a solid. When a push rod presses against a piston inside a cylinder containing liquid, the liquid is pushed out the other side. If Cylinder A is connected by a tube to Cylinder B, the liquid moving into the second cylinder will press its piston down the cylinder, pushing its push rod out of the cylinder.



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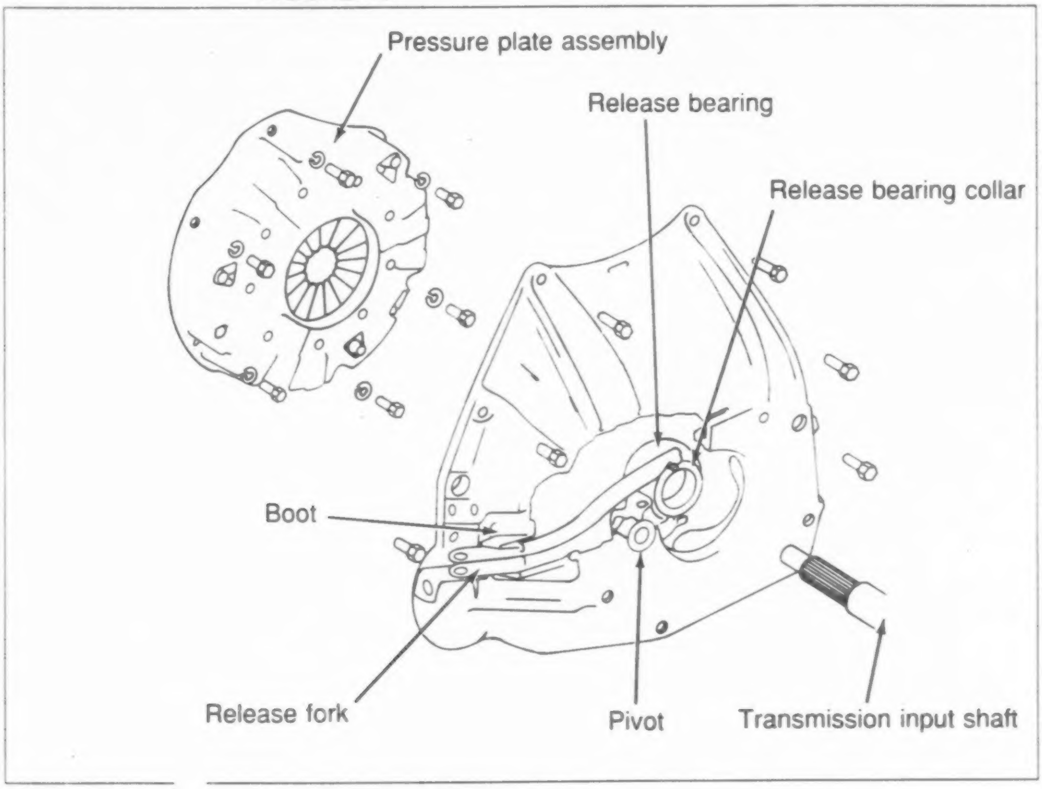
NOTE: It is important to note that there is absolutely no air between the pistons in the two cylinders. Even the slightest pressure against the piston in Cylinder A causes the piston in Cylinder B to move. This efficiency of motion makes hydraulic clutches very responsive.

Operation of a Hydraulic Clutch (Refer to Figure 12):

1. In a hydraulic type clutch linkage, the driver's foot on the clutch pedal presses the push rod against the piston inside the clutch master cylinder.
2. As the piston moves down the master cylinder, it pushes the hydraulic fluid into the flexible hydraulic line.
3. The hydraulic fluid moves through the line, applying pressure on the piston inside the slave cylinder.
4. As this piston is moved down the slave cylinder by the pressure of the hydraulic fluid, the slave cylinder push rod is pressed out of the housing.
5. The exiting slave cylinder push rod presses the release fork against the release bearing.
6. When the clutch pedal is no longer pressing the push rod into the master cylinder, the return springs in the master cylinder and the slave cylinder cause the pistons in both cylinders to return to their original positions.

OBJECTIVE 9 **Label the parts involved in the clutch release mechanism on an illustration.**

FIGURE 13


Pressure plate assembly
Release bearing
Release bearing collar
Boot
Release fork
Pivot
Transmission input shaft

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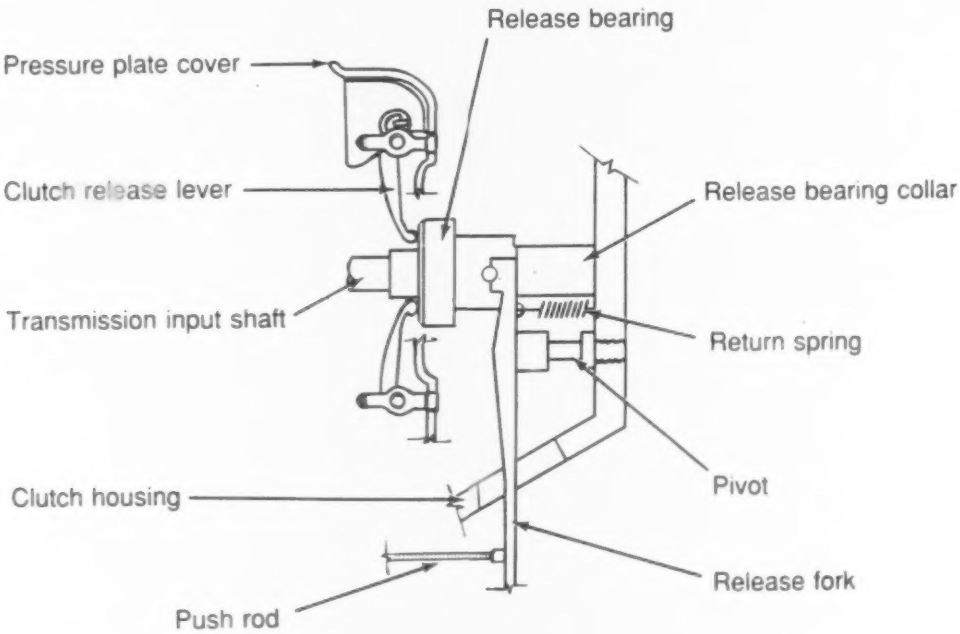
NOTE: The release bearing is sometimes called a ***throwout bearing***, and the release fork is also known as the ***release lever*** or ***throwout lever***.

OPERATION OF THE CLUTCH RELEASE MECHANISM

The release fork is attached to the collar of the release bearing on one end and extends out of the clutch housing on the other. The release bearing is positioned around the transmission input shaft.


Release bearing
Pressure plate cover
Clutch release lever
Release bearing collar
Transmission input shaft
Return spring
Pivot
Clutch housing
Release fork
Push rod

1. When the release fork is pulled or pushed by the clutch linkage, it pivots on the release fork pivot.
2. The part of the release fork that is attached to the release bearing collar pushes the release bearing against the pressure plate assembly, disengaging the clutch.
3. When the clutch pedal stops pulling or pushing on the release fork, the return spring attached to the release fork pulls the release fork and the release bearing away from the pressure plate assembly.

CLUTCH TROUBLESHOOTING GUIDE

Use Supplements 2, 3, & 4, ***Clutch Performance Diagnosis Chart***, ***Clutch Noise Diagnosis Chart***, and ***Transmission Problems That Are Clutch-Related***, to assist with diagnosing clutch problems.

1. **Talk to the vehicle's owner.** The first step in diagnosing any automotive problem is to talk to the vehicle's owner about the nature of the problem and the service history of the vehicle.

2. **Make a diagnostic road test.** Make a diagnostic road test to verify the symptoms described by the vehicle's owner. Drive the vehicle under the conditions at which the symptoms are reported to appear. If you cannot get the same results described by the customer, conduct the road test with the customer driving. Sometimes the customer is oversensitive to normal noises and performance or his/her driving habits result in undesirable performance. Review Supplement 3, Unit 1 for general guidelines for "Making a Diagnostic Road Test."

3. **Measure and adjust clutch pedal free travel and check and lubricate the clutch linkage.** Many clutch problems are caused by improper clutch pedal free travel adjustment. Before making any diagnostic tests, measure clutch pedal free travel (See instructions in Supplement 5.) and make sure it is adjusted within specifications. If the clutch pedal free travel needs adjustment, use the opportunity to check and lubricate the parts of the clutch linkage outside the clutch housing.

4. **Inspect the clutch housing for possible lubrication leaks.** Oil or grease in the clutch housing can cause a variety of clutch problems. Inspect the clutch housing for evidence of a lubrication leak. If there is a leak, it must be repaired, the clutch housing and clutch assembly thoroughly cleaned, and the clutch disc (and possibly the pressure plate assembly) replaced.

5. **Make a dynamic shift test.**

   (1) Conduct this test on a smooth, flat surface.
   (2) Press the clutch pedal to release the clutch.
   (3) Start the engine and shift into neutral.
   (4) Release the clutch pedal, engaging the clutch. Do not accelerate.

(5) Note any unusual operation or noises.
(6) Press the clutch pedal and shift into first.
(7) Release the clutch pedal, engaging the clutch.
(8) Repeat the process, shifting into all the speed ranges.
(9) Note any unusual operation or noises in each speed.

6. **Check for clutch slippage.** *Clutch slippage* occurs when the clutch disc is not clamped firmly between the pressure plate and the flywheel when the clutch is engaged. If the vehicle does not run as fast as the engine, the clutch could be slipping. Slipping is especially noticeable when engaging the clutch from a dead stop.

◆ WARNING ◆

Do not let anyone stand in front of the vehicle during this test. The vehicle can jump forward violently.

(1) Set the parking brake and put blocks around the vehicle's front wheels.
(2) Turn on the engine, shift into neutral, and let the engine run until the indicator shows that the engine has reached its normal operating temperature.

◆ WARNING ◆

If you are running the engine in a closed garage, make sure the vehicle's exhaust is properly vented.

(3) Depress the clutch pedal, shift the transmission into high gear, and depress the accelerator until engine speed reaches about 2,000 rpm or the manufacturer's specified rpm.
(4) Slowly release the clutch pedal until the clutch is fully engaged.

CAUTION

Do not engage the clutch for any longer than five seconds or clutch damage will result.

(5) If the engine stalls immediately, the clutch is not slipping.
(6) If the engine doesn't stall, re-check the clutch linkage and engine and transmission mounts for probiems and repeat this test before disassembling the clutch for a visual inspection. If there is a clutch inspection cover, remove it and check for metal and facing material inside the clutch housing—a sign of clutch slippage.

7. **Check for clutch chatter.** *Clutch chatter* is a shuddering vibration felt throughout the vehicle when the clutch disc is first contacted by the pressure plate. Clutch chatter will stop when the clutch is fully engaged.

   (1) Perform this test during a road test on a smooth, level road.
   (2) Start the vehicle, shift into 1st gear, and accelerate until engine speed reaches about 1,500 rpm.
   (3) Slowly release the clutch pedal and watch for clutch chatter when the clutch disc is first contacted by the pressure plate.
   (4) Depress the clutch pedal fully and reduce engine speed.
   (5) Shift into reverse and accelerate until engine speed reaches about 1,500 rpm.
   (6) Slowly release the clutch pedal and watch for clutch chatter when the clutch disc is first contacted by the pressure plate.
   (7) If there is no clutch chatter, increase the engine speed to 2,000 rpm and repeat steps 3-6.
   (8) If clutch chatter is present, re-check the clutch linkage, engine and transmission mounts, and transmission and clutch housing bolts. If repairs or adjustments are made, repeat this test before disassembling the clutch for a visual inspection. Most clutch chatter problems originate inside the clutch assembly.

8. **Check for clutch drag.** When the clutch disc does not come to a complete stop within 5 seconds after being disengaged, the condition is called *clutch drag*. Clutch drag can cause hard shifting or cause gears to clash when shifting into reverse.

   NOTE: It normally takes about 5 seconds for the clutch disc to stop spinning when the clutch is disengaged. This condition, called *spin-down time*, should not be confused with clutch drag. Larger clutch discs have a longer spin-down time. Check the service manual for the spin-down specification on the vehicle you are using.

   (1) Perform this test with the vehicle on a smooth, level road.
   (2) Start the vehicle and depress the clutch pedal.
   (3) Shift into 1st and release the clutch pedal but do not press the accelerator pedal.
   (4) Depress the clutch pedal and shift into neutral but do not release the clutch pedal after shifting.
   (5) Wait 5-10 seconds and shift into reverse, releasing the clutch pedal after the shift.

(6) If there was gear clash when the vehicle was shifted into reverse, re-check the clutch linkage and repeat this test before disassembling the clutch for a visual check.

9. **Check for clutch pulsation.** *Clutch pulsation* is a very rapid in-and-out motion of the clutch pedal which occurs when the release bearing first touches the pressure plate assembly.

(1) Perform this test during a test on a smooth, level road.
(2) Start the vehicle and drive at a moderate speed.
(3) Slowly depress the clutch pedal and observe any clutch pulsation as the clutch pedal just begins to disengage the clutch.
(4) Watch for pulsations as you completely depress the clutch pedal.
(5) If there is little or no pulsation, this problem does not exist.
(6) If there is clutch pulsation, the clutch must be disassembled and inspected.

10. **Check for clutch vibration.** *Clutch vibration* is a slower vibration motion than clutch pulsation and it is felt throughout the vehicle, not only in the clutch pedal. Occurring with the clutch pedal in any position, clutch vibration usually appears at engine speeds over 1,500 rpm.

(1) Perform this test during a test on a smooth, level road.
(2) Start the vehicle and bring the engine rpm up to 1,500 rpm.
(3) Observe any clutch vibration as you increase the rpm over 1,500.
(4) If clutch vibration exists, raise the vehicle and check the engine and transmission mounts and any other part that might be rubbing against the body or frame.
(5) If a problem is found, correct it and re-check for vibration.
(6) If vibration still exists and the mounts are OK, remove the drive belts one at a time to determine if any of the accessories is the cause of the vibration.

CAUTION

Do not run the engine for more than one minute at a time with the belts removed.

(7) Check the crankshaft vibration damper for damage before disassembling the clutch for a visual check.

11. **Listen for clutch noise.** Most clutch noises are heard best when the engine is idling.

    - Noises that are heard when the clutch pedal is moving are probably related to the clutch linkage.
    - A noise that is heard while the transmission is in neutral but disappears when the clutch pedal is depressed is probably a transmission noise.
    - Whirring, grating, or grinding noises could be a release bearing or the transmission input shaft.
    - High-pitched whining or squealing noises are from the release bearing or the pilot bearing/bushing. Pilot bushing/bearing noises are best heard when the clutch is cold.
    - Use Supplement 3, "Clutch Noise Diagnosis Chart," to help you diagnose clutch noises.

12. **Disassemble, inspect, and repair or replace the clutch.** Use Job Sheets 1-13 to assist in removing, inspecting, adjusting, and replacing clutch components. Be sure you cure the cause of the problem, not just the symptom.

CLUTCH PERFORMANCE DIAGNOSIS CHART

Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Clutch failure—no power being transmitted	Clutch disc facings torn off or worn out	Replace clutch disc
	Weak, broken, or worn spring(s) in pressure plate assembly	Replace pressure plate assembly
	Faulty clutch pedal action	Check for bent clutch pedal or floor mat under pedal
	Improper clutch pedal free travel adjustment	Adjust free travel
	Hub torn from clutch disc	Replace clutch disc
	Clutch disc hub stuck on transmission input shaft splines	Repair or replace transmission input shaft and/or clutch disc
Clutch fails to disengage	Improper clutch pedal free travel adjustment	Adjust free travel
	Worn, dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Leak in hydraulic clutch linkage	Inspect and repair hydraulic linkage
	Worn cable in cable clutch linkage	Replace cable
	Warped, worn, or damaged clutch disc or pressure plate assembly	Replace clutch disc or pressure plate assembly
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring

CLUTCH PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Clutch fails to disengage (continued)	Clutch disc hub binding on transmission input shaft splines	Repair or replace transmission input shaft and/or clutch disc
	Faulty clutch pedal action	Check for bent clutch pedal or floor mat under pedal
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
	Release bearing improperly installed on release fork	Install correctly
	Release fork off pivot	Install and lubricate
Clutch pedal stays on floor when disengaged	Weak, broken, or worn spring(s) in pressure plate assembly	Replace pressure plate assembly
	Cable clutch linkage binding, broken, or disengaged	Repair cable clutch linkage
	Weak or damaged clutch linkage return spring	Replace spring and assure that clutch pedal returns fully
	Seal failure in master cylinder of hydraulic clutch linkage	Repair or replace unit and bleed system
	Bind in clutch linkage or release bearing	Lubricate and free linkage or release bearing
Clutch pedal hard to depress	Dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Faulty clutch pedal action	Check for bent clutch pedal or floor mat under pedal
	Worn clutch disc	Replace clutch disc
	Release fork binding	Free, adjust, and lubricate release fork
Clutch pedal feels "spongy" when depressed	Air in hydraulic clutch linkage	Check fluid level and bleed system—check and replace parts if symptom recurs

CLUTCH PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Clutch slips when engaged	Weak, broken, or worn spring(s) in pressure plate assembly	Replace pressure plate assembly
	Oil/grease on clutch disc facings	Replace clutch disc and fix oil leak
	Improver clutch pedal free travel adjustment	Adjust free travel
	Worn, torn, or burned clutch disc facings	Replace clutch disc
	Worn, damaged, or warped clutch disc, pressure plate assembly or flywheel	Replace clutch disc or pressure plate assembly; repair or replace flywheel
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Clutch disc not seated	Make 30 to 40 normal clutch engagements **CAUTION** Do not overheat.
	Levers on pressure plate assembly binding or sticking	Lubricate levers or replace pressure plate assembly
	Clutch disc overheated	Allow to cool
	Worn, dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Worn or damaged master or slave cylinder in hydraulic clutch linkage	Clean and service or replace unit
	Overfilled reservoir in hydraulic clutch linkage	Remove excess fluid
	Clutch disc hub binding on transmission input shaft splines	Repair or replace transmission input shaft and/or clutch disc

CLUTCH PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Clutch slips when engaged (continued)	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
	Broken engine mount	Replace mount
Clutch grabs or chatters when engaged	Damaged or warped clutch disc, pressure plate assembly, or flywheel	Replace clutch disc or pressure plate assembly; repair or replace flywheel
	Oil/grease on clutch disc facings	Replace clutch disc and fix oil leak
	Failure of torsional dampener spring in clutch disc	Replace clutch disc
	Clutch disc hub binding on transmission input shaft splines	Replace transmission input shaft and/or clutch disc
	Weak, broken, or worn spring(s) in pressure plate assembly	Replace pressure plate assembly
	Levers on pressure plate assembly binding or sticking	Lubricate levers or replace pressure plate assembly
	Burned, glazed, or loose clutch disc facings	Replace clutch disc
	Worn, spongy, loose, or broken engine mounts	Replace mounts
	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
	Loose clutch disc rivets	Replace clutch disc
	Burned or smeared resin on flywheel or pressure plate	Smooth off with emery cloth if slight damage; replace if substantial damage
	Worn or damaged splines on clutch disc or transmission input shaft	Replace clutch disc and/or transmission input shaft
	Bent transmission input shaft	Replace shaft

CLUTCH PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Clutch grabs or chatters when engaged (continued)	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Weak or broken return spring in clutch linkage	Replace spring
	Worn, dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Improper clutch pedal free travel adjustment	Adjust free travel
Clutch spins or drags when disengaged	Warped clutch disc or pressure plate assembly	Replace clutch disc or pressure plate assembly
	Binding between clutch disc and transmission input shaft	Clean and lubricate splines on clutch disc and transmission input shaft; replace damaged parts
	Improper clutch pedal free travel adjustment	Adjust free travel
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
	Release bearing improperly installed on release fork	Install correctly
	Loose clutch disc facings	Replace clutch disc
	Oil/grease on clutch disc facings	Replace clutch disc and repair oil leak
	Excessive dust in clutch	Remove dust

CLUTCH PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Clutch spins or drags when disengaged (continued)	Worn, dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Broken engine mounts	Replace mounts
Vibrations	Loose flywheel mounting bolts	Torque bolts to specification
	Excessive flywheel runout	Repair or replace flywheel
	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
	Defective clutch disc	Replace clutch disc
	Bent transmission input shaft	Replace shaft
	Excessive clutch housing face or bore runout	Replace clutch housing
	Rigid clutch disc installed instead of a flexible disc	Install a flexible clutch disc
	Dust in the clutch assembly	Remove dust
Pulsations in clutch pedal	Warped clutch disc, pressure plate assembly, or flywheel	Replace clutch disc or pressure plate assembly; repair or replace flywheel
	Improper assembly of pressure plate to flywheel	Install correctly
	Defective clutch disc	Replace clutch disc
	Weak, broken, or worn spring(s) in pressure plate assembly	Replace pressure plate assembly
	Excessive clutch housing face or bore runout	Replace clutch housing
	Damaged diaphragm spring	Replace pressure plate assembly

CLUTCH NOISE DIAGNOSIS CHART

Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Clutch squeaks or scrapes when clutch pedal is depressed	Dry, dirty, damaged, binding, or misaligned clutch linkage	Clean, inspect, align, and lubricate clutch linkage
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Dry pilot bearing/bushing	Lubricate bearing/bushing; replace if needed
	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
Rattling	Release fork loose on pivot or release bearing	Check and correct assembly of release bearing, release fork, and pivot
	Failure of torsional dampener spring in clutch disc	Replace clutch disc
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Weak, broken, or worn spring(s) in pressure plate assembly	Replace pressure plate assembly
	Weak or broken return spring in clutch linkage	Replace spring

CLUTCH NOISE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Rattling (continued)	Oil in clutch disc torsional dampener spring	Replace clutch disc and fix oil leak
	Bent transmission input shaft	Replace shaft
	Worn or damaged splines on clutch disc or transmission input shaft	Replace clutch disc and/or transmission input shaft
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
Release bearing noise with clutch engaged	Improper clutch pedal free travel adjustment	Adjust free travel
	Release bearing binding on transmission input shaft's bearing retainer	Clean, relubricate, check for burns, nicks, etc.
	Release fork improperly installed	Install properly
	Worn, damaged, or dry release bearing	Replace release bearing
	Weak or damaged clutch linkage return spring	Replace spring
Noise with clutch disengaged	Worn, damaged, or dry release bearing	Replace release bearing
	Release fork off pivot (heavy clicking)	Install and lubricate properly
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
	Misalignment of engine block, transmission, and clutch housing	Correct misalignment

CLUTCH NOISE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Noise with clutch disengaged (continued)	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Worn diaphragm spring	Replace pressure plate assembly

TRANSMISSION PROBLEMS THAT ARE CLUTCH-RELATED

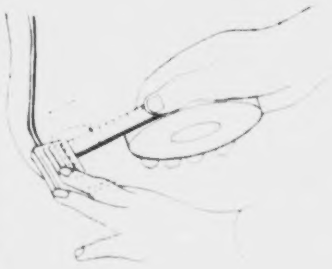
Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Gears clash when shifting	Improper clutch pedal free travel adjustment	Adjust free travel
	Dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
Transmission shifts hard	Improper clutch pedal free travel adjustment	Adjust free travel
	Dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
Transmission jumps out of gear	Misalignment of engine block, transmission, and clutch housing	Correct misalignment
	Excessive crankshaft end play	Correct crankshaft end play
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing

GUIDELINES FOR INSPECTING, ADJUSTING, AND REPLACING CLUTCH LINKAGES

- Check clutch pedal free travel whenever any part of the clutch is removed for service, repair, or replacement. (See information on the next page.)
- Adjust the clutch linkage if the clutch pedal free travel is not within specifications or if there is any evidence that the clutch is not engaging or disengaging correctly.
- Always inspect each part of the clutch linkage and measure clutch pedal free travel before attempting to adjust the clutch.
- Clean the parts of the clutch linkage before inspection, using an approved cleaning solvent if necessary.
- Refer to the vehicle's service manual for a diagram of the vehicle's clutch linkage and use the diagram to inspect the linkage, checking for missing, warped, damaged, or worn parts.
- Check assist or return springs to make sure they are not warped or have lost their flexibility.
- Don't forget to check the parts of the clutch linkage inside the vehicle, making sure they are in good condition and not loose, damaged, or worn.
- Replace any missing, damaged, or worn parts before attempting to adjust the linkage.
- If the clutch linkage must be disassembled, be sure to keep small parts together.

MEASURING CLUTCH PEDAL FREE TRAVEL



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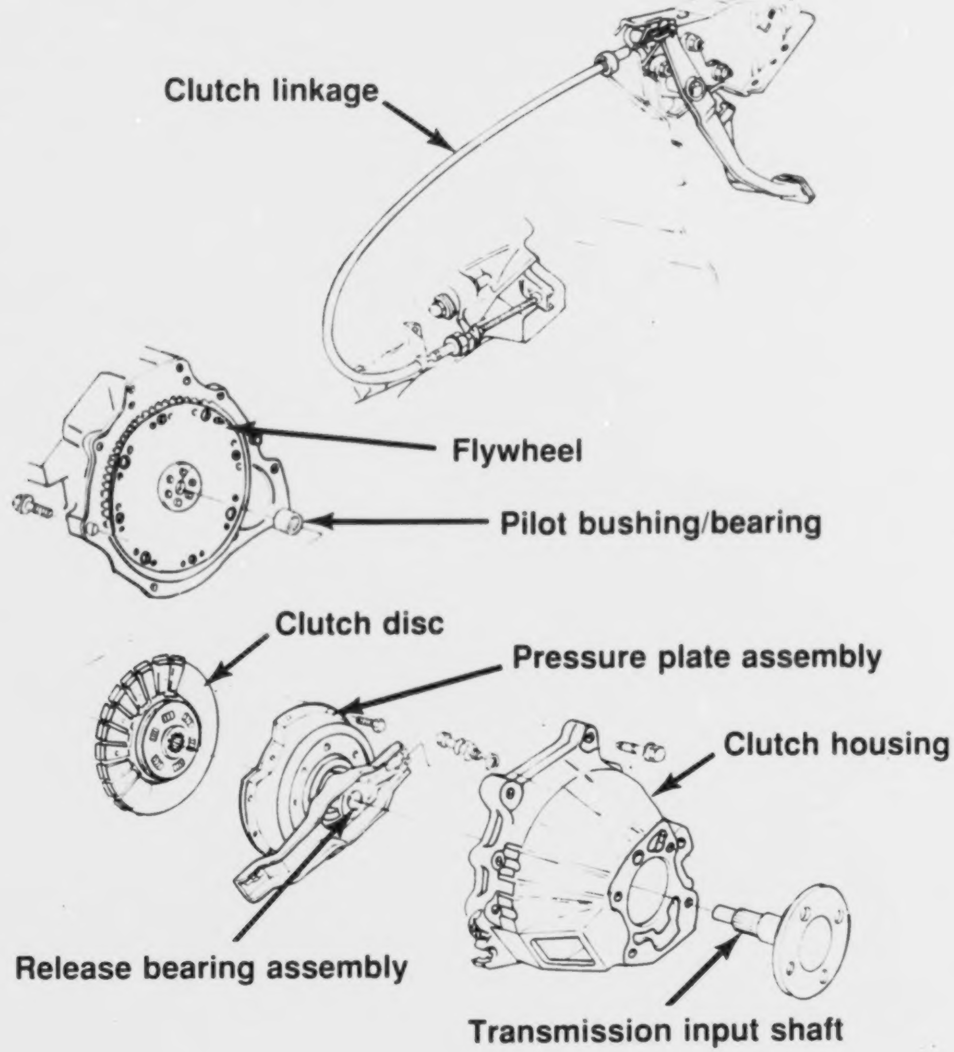
Manufacturers specify different methods of measuring clutch pedal free travel. This is one method. Check the vehicle's service manual for the method suggested for the vehicle you are servicing.

1. Remove any floor mats or removable carpet underneath the clutch pedal.
2. Rest the end of a ruler or tape measure on the floor of the car beside the clutch pedal.
3. Hold the ruler parallel to the movement of the clutch pedal as it is depressed.
4. Measure the distance from the floor to the top of the clutch pedal.
5. Use *one finger* to press down the clutch pedal until you feel resistance.
6. Measure the distance from the floor to the top of the clutch pedal at this point.
7. Subtract the second measurement from the first measurement—this is the amount of clutch pedal free travel. This measurement is usually about ¾ to 1 inch on most vehicles, but the measurement should always be checked against the manufacturer's specification.

Major Components of the Clutch System


Clutch linkage
Flywheel
Pilot bushing/bearing
Clutch disc
Pressure plate assembly
Clutch housing
Release bearing assembly
Transmission input shaft

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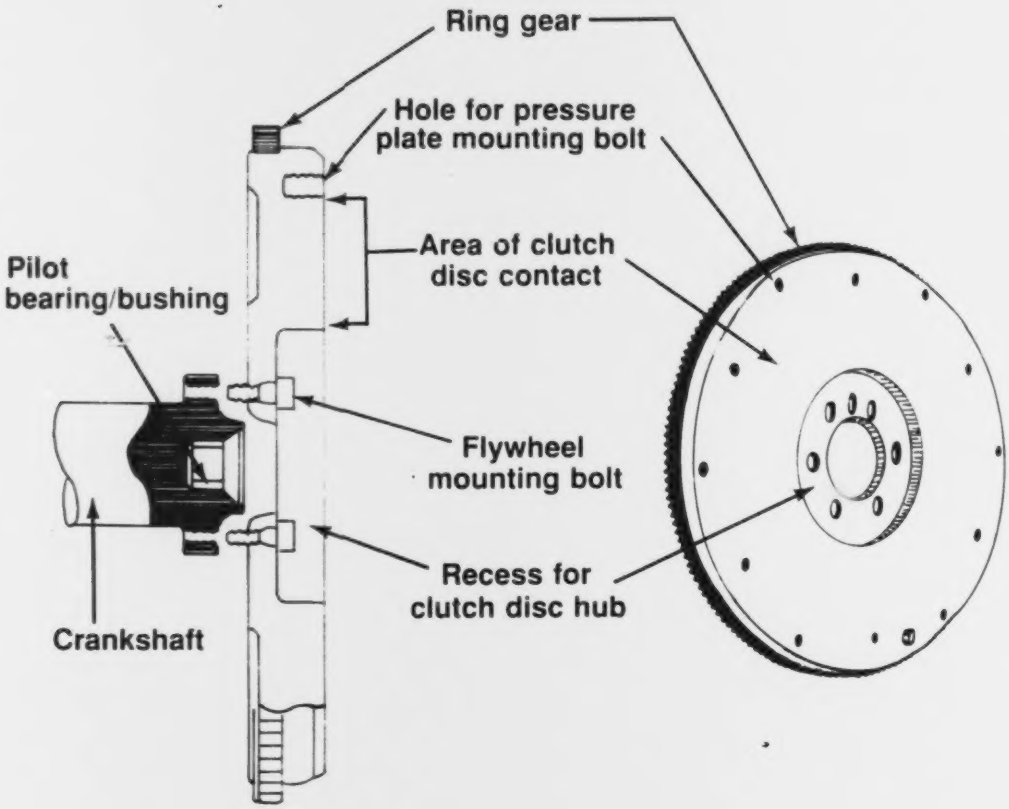
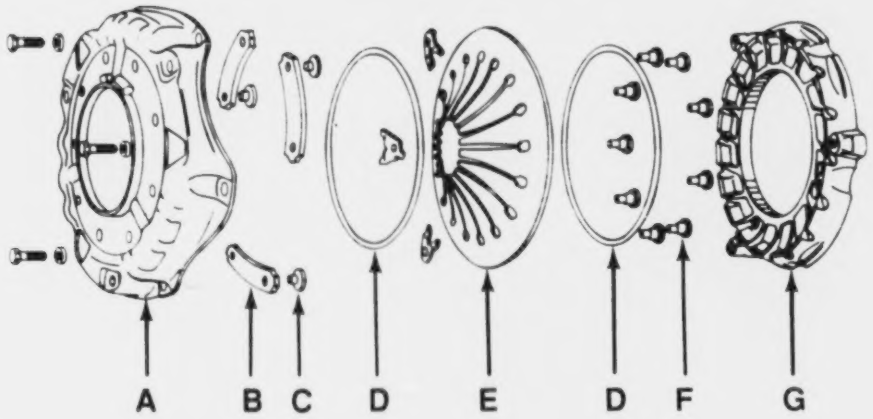
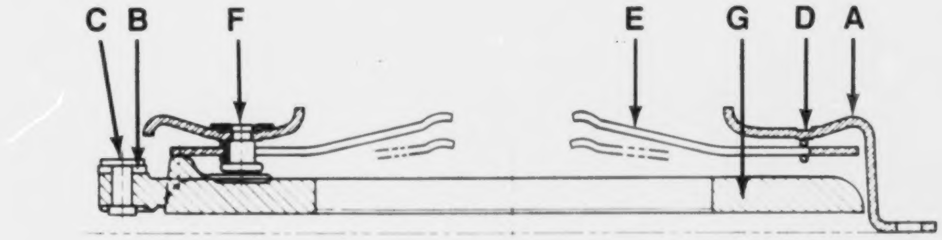
Parts of a Flywheel


Ring gear
Hole for pressure plate mounting bolt
Area of clutch disc contact
Pilot bearing/bushing
Flywheel mounting bolt
Recess for clutch disc hub
Crankshaft

Diaphragm Spring Type Pressure Plate Assembly



- A. Pressure plate cover
- B. Drive strap
- C. Drive strap rivet
- D. Gasket
- E. Diaphragm spring
- F. Spring pivot rivet
- G. Pressure plate



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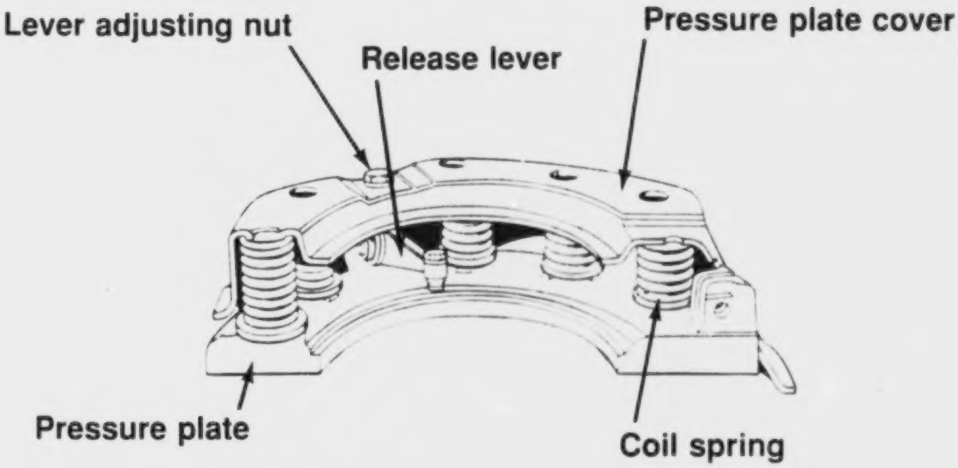
Lever Type
Pressure Plate Assembly


Lever adjusting nut
Release lever
Pressure plate cover
Pressure plate
Coil spring

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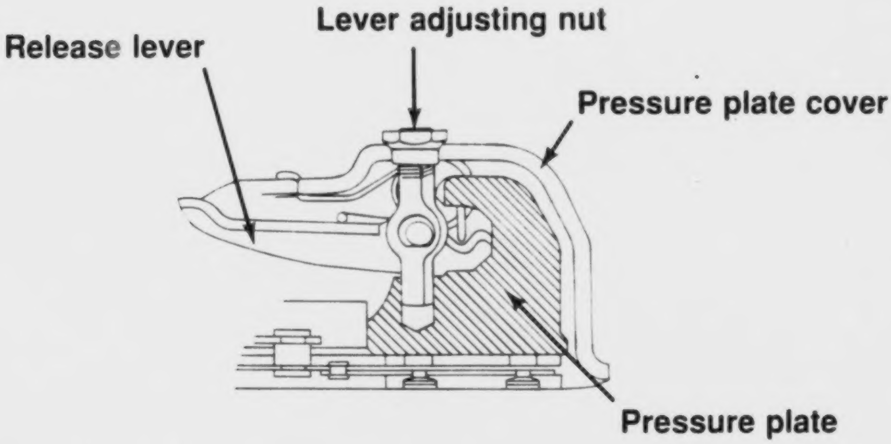
Release lever
Lever adjusting nut
Pressure plate cover
Pressure plate

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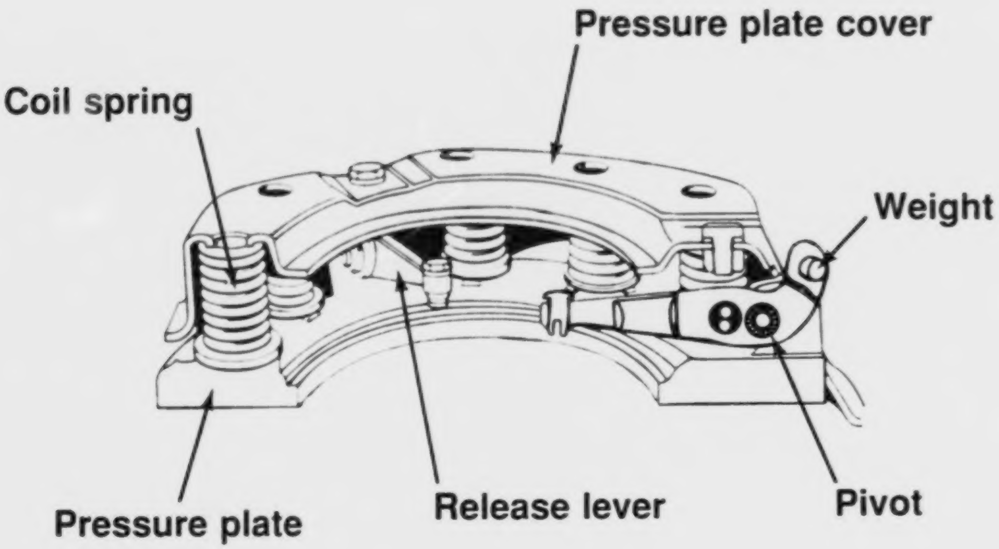
Semi-Centrifugal Type Pressure Plate Assembly


Pressure plate cover
Coil spring
Weight
Pressure plate
Release lever
Pivot

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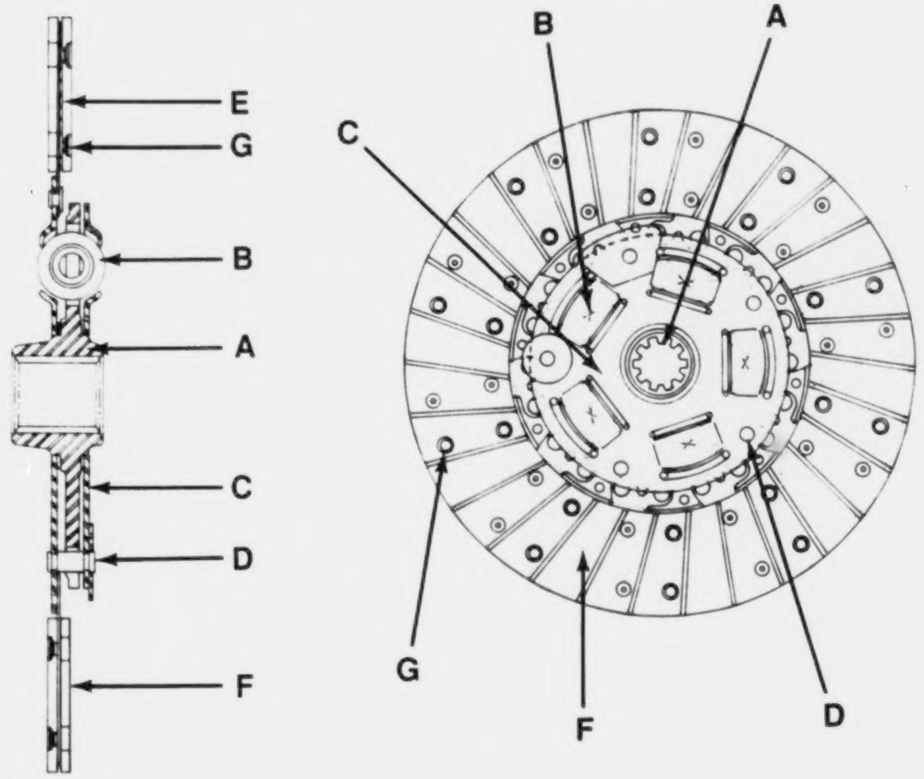
Parts of a Clutch Disc



A. Hub and Hub Flange
B. Torsional Dampener Springs
C. Side Plates
D. Stop Pins
E. Cushion Springs
F. Facings
G. Rivets

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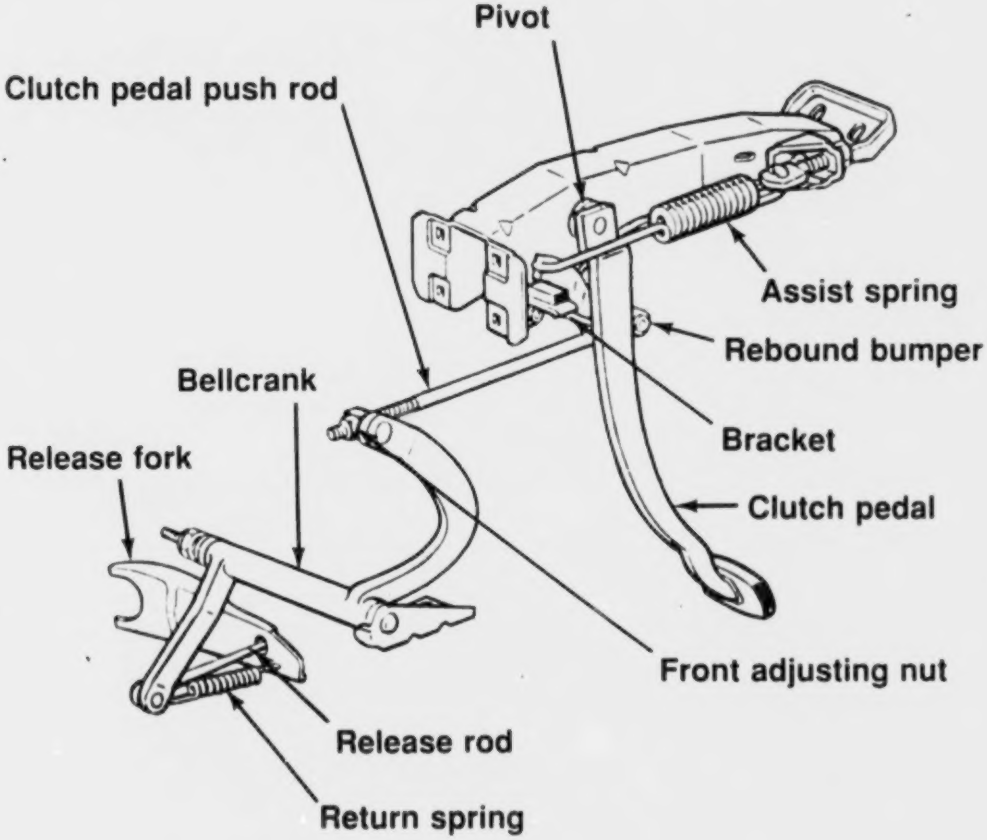
Rod and Lever Type Clutch Linkage


Pivot
Clutch pedal push rod
Assist spring
Rebound bumper
Bellcrank
Bracket
Release fork
Clutch pedal
Front adjusting nut
Release rod
Return spring

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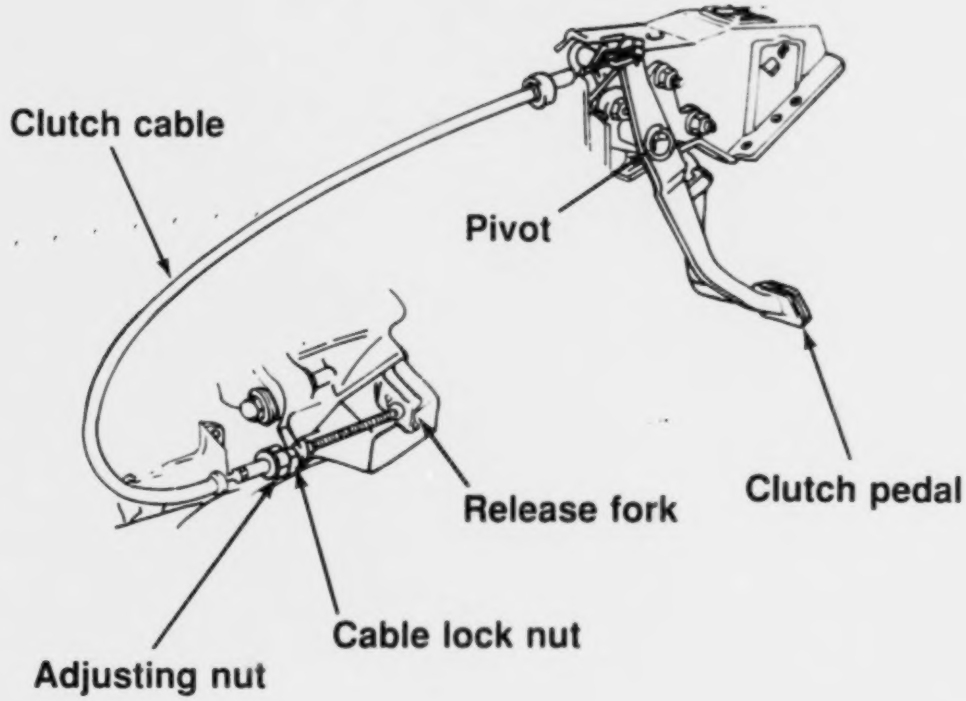
Cable Type Clutch Linkage


Clutch cable
Pivot
Release fork
Clutch pedal
Cable lock nut
Adjusting nut

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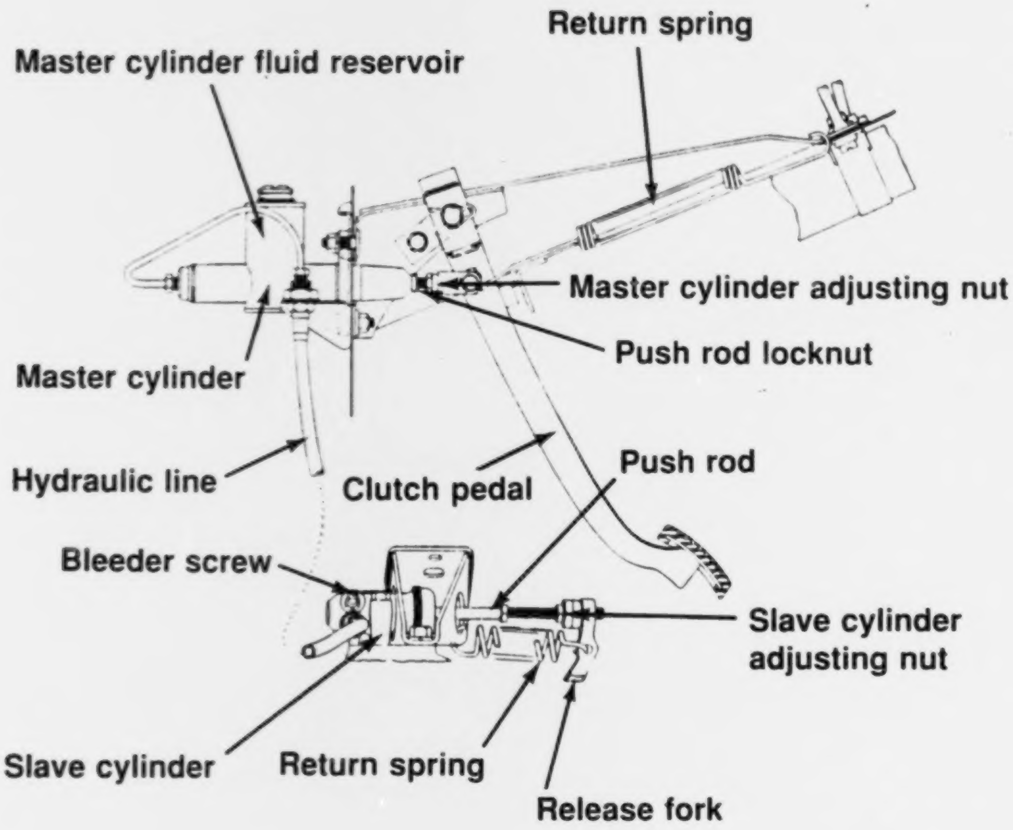
Hydraulic Clutch Linkage


Return spring
Master cylinder fluid reservoir
Master cylinder adjusting nut
Push rod locknut
Master cylinder
Hydraulic line
Clutch pedal
Push rod
Bleeder screw
Slave cylinder
adjusting nut
Slave cylinder
Return spring
Release fork

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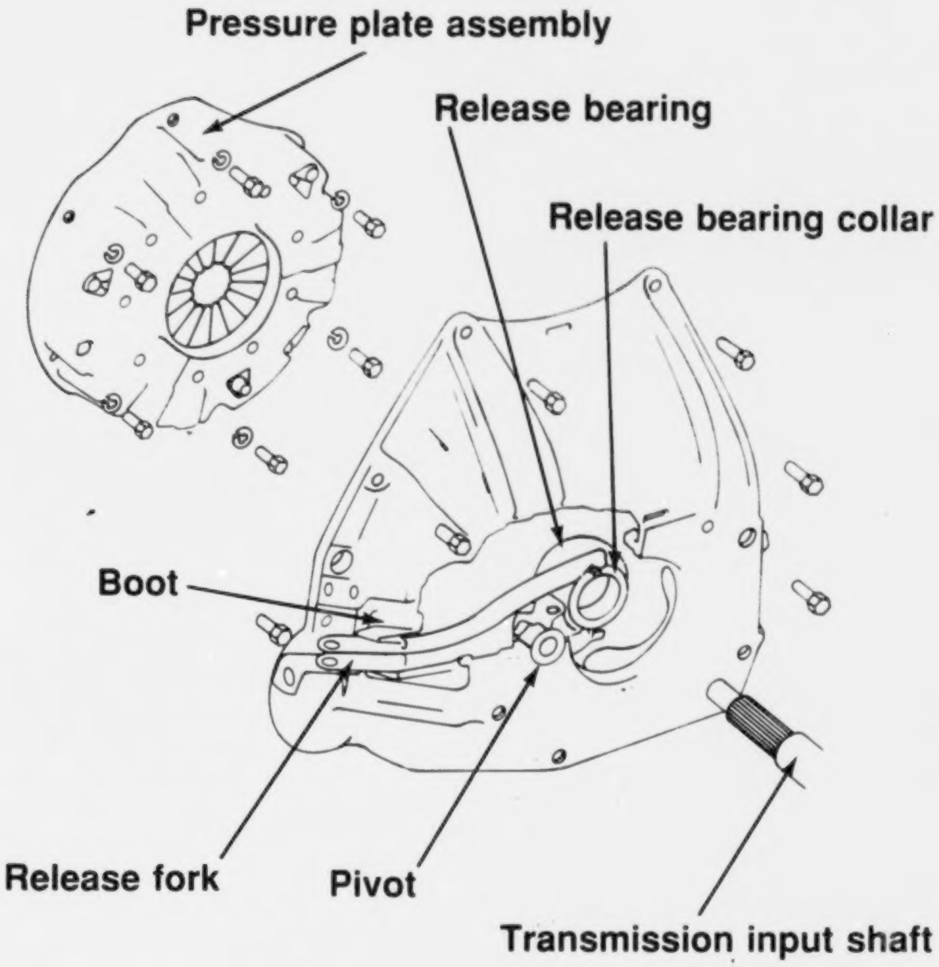
Parts of the Clutch Release Mechanism


Pressure plate assembly
Release bearing
Release bearing collar
Boot
Release fork
Pivot
Transmission input shaft

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ASSIGNMENT SHEET 1

SERVICE CLUTCHES

NAME ______________________________ SCORE ________

OBJECTIVE 10

Diagnose clutch noise and performance problems.

INTRODUCTION

A major investment of time and effort is required to visually examine the components in a clutch assembly—the driveline, transmission, and clutch housing must first be removed. Because of this, efforts at clutch diagnosis should always first give careful attention to diagnostic tests and visual checks of more readily accessible causes of clutch noise and performance problems.

- Conduct a diagnostic road test for clutch problems.
- If equipped, inspect the clutch assembly through an inspection cover.
- Measure and adjust clutch pedal free travel.
- Inspect, adjust, and lubricate the clutch linkage.
- Inspect the engine and transmission mounts and transmission and clutch housing bolts.
- Check for lubrication leaks that may contaminate the clutch assembly.
- Make a dynamic shift test.
- Make diagnostic tests for clutch slippage, chatter, drag, pulsation, vibration, and noise.

Making these initial checks and correcting any problems they uncover is the most cost-effective method of beginning clutch diagnosis. Supplement 1, ***Clutch Troubleshooting Guide***, will guide you through the process of clutch diagnosis. Use Supplement 2, ***Clutch Performance Diagnosis Chart***, Supplement 3, ***Clutch Noise Diagnosis Chart***, and Supplement 4, ***Transmission Problems That Are Clutch-Related***, to help you with your diagnosis.

DIRECTIONS

Study the Student Supplements mentioned just above, and then read each of the following questions carefully. Select the answer for each that is *most* correct. Write the correct letter in the blank.

______1. When you first engage the clutch, the whole vehicle shudders. What is this clutch problem called?

A. Clutch vibration
B. Clutch chatter
C. Clutch slippage
D. Clutch drag

_______2. A high-pitched squealing noise is coming from the area of the clutch. What is the most probable cause?

A. Low hydraulic fluid
B. Slipping clutch disc
C. Worn pressure plate levers
D. Bad pilot bearing/bushing

_______3. You push the clutch pedal down and it stays there. Which of the following is **not** a possible cause?

A. Broken clutch linkage cable
B. Broken clutch disc
C. Broken return spring
D. Failed seal in slave cylinder

_______4. The clutch is slipping. Technician A says the cause could be oil on the clutch disc facings. Technician B thinks it could be weak springs in the pressure plate assembly. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_______5. Removing the accessory drive belts one by one is part of the check to uncover the source of:

A. Clutch vibration
B. Clutch slippage
C. Clutch drag
D. Clutch noise

_______6. You hear a noise when the transmission is in neutral, but it disappears when you depress the clutch pedal. What is the most likely cause?

A. Bad release bearing
B. Clutch slippage
C. Transmission problems
D. Clutch linkage

______7. Which of the following possible causes of clutch slippage should be checked **last**?

A. Improper clutch pedal free travel
B. Loose transmission mount
C. Levers on pressure plate assembly sticking
D. Overfilled reservoir on master cylinder

______8. Refer to your answer to the above question—**why** should this cause of clutch slippage be checked last?

A. Because it is the least likely cause
B. Because it involves the most expensive component to replace
C. Because it is the hardest to replace
D. Because it is the most difficult to reach in order to check

______9. Technician A says that the clutch pedal free travel should be checked and adjusted **before** making other diagnostic tests. Technician B says that free travel should be corrected only if another diagnostic test shows that correction is needed. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____10. There is a little oil on the clutch disc facings. What is the appropriate corrective action?

A. Clean the facings with an approved cleaning solvent
B. Replace the facings
C. Replace the clutch disc
D. Replace the clutch disc and repair the oil leak

_____11. What is the normal maximum spin-down time for the average clutch disc after the clutch is disengaged?

A. 1 second
B. 2 seconds
C. 5 seconds
D. 10 seconds

_____12. The clutch drags when disengaged. What is the most likely cause?

A. Loose flywheel mounting bolts
B. Warped clutch disc
C. Excessive clutch housing face or bore runout
D. Overfilled hydraulic reservoir

_____13. There is a scraping noise when the clutch pedal is depressed. Technician A says it could be binding between the clutch disc and the transmission input shaft. Technician B thinks it may be a dry clutch disc. Who is correct?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____14. Which of the following diagnostic procedures should be done **first**?

A. Diagnostic road test
B. Talk to vehicle owner
C. Inspect the clutch
D. Check the vehicle's service manual

_____15. A vehicle that had its clutch disc replaced two months ago is in the shop again with a slipping clutch. The clutch linkage and release bearing mechanism check out OK, but clutch disc facing material can be seen through the inspection cover. Technician A wants to run some tests to see if all the parts of the clutch assembly are in good working order. Technician B says this is not cost effective, they should just replace the clutch disc. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

ASSIGNMENT SHEET 1

1. B
2. D
3. B
4. C
5. A
6. C
7. C
8. D
9. A
10. D
11. C
12. B
13. D
14. B
15. A

JOB SHEET 1

SERVICE CLUTCHES

III

OBJECTIVE 11A

Inspect, adjust, and replace rod and lever type clutch linkage components.

INTRODUCTION

Rod and lever type clutch linkages are found on older vehicles and larger vehicles. The linkage consists of a series of rods and levers, operating on pivot points which on newer vehicles are usually made of low-friction plastic. During normal wear, the parts of the clutch linkage become worn and because of this wear the driver must push the clutch pedal down farther before the release fork will press the release bearing against the pressure plate assembly.

The distance the clutch pedal moves before the release bearing contacts the pressure plate assembly is called ***clutch pedal free travel***. A certain amount of clutch pedal free travel is normal and desirable, but too little or too much can cause a number of problems. Too little free travel can cause the release bearing to constantly ride on the diaphragm spring or release levers of the pressure plate assembly, causing increased wear and clutch slippage. Too much free travel may cause the clutch not to disengage completely, causing clutch wear and transmission gear damage. Adjusting the vehicle's clutch pedal free travel is called ***adjusting the clutch***. Improper adjustment of clutch pedal free travel is one of the most common causes of clutch failure and can cause transmission failure.

CLUTCH DISC WEAR AFFECTS CLUTCH PEDAL FREE TRAVEL

The amount of wear on the clutch disc facings can also affect clutch pedal free travel. As the facings on the clutch disc become worn, the overall thickness of the clutch disc is reduced. The pressure plate inside the pressure plate assembly must move closer to the flywheel in order to clamp the clutch disc, engaging the clutch. As the pressure plate moves closer to the flywheel, the free end of the pressure plate levers (or fingers of the diaphragm spring) move closer to the release bearing, reducing clutch pedal free travel.

On a rod and lever type clutch linkage, the clutch is adjusted by adjusting the length of one of the linkage rods—usually either the rod which pushes the release fork or the rod which is pushed by the clutch pedal. All clutch linkages have a clutch pedal and some type of release fork, but the parts of the linkage in between come in such a wide variety of arrangements, that giving a "standard" procedure for their adjustment and service is not possible.

Adjustment hint for rod and lever type linkages: One of the most frequent adjustment problems on rod and lever type linkages occurs when the angle between the bellcrank mounting and the transmission and frame is incorrect. Check your service manual for the correct mounting angle.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle with a rod and lever type clutch linkage
- Supplement 5, ***Guidelines for Inspecting, Adjusting, and Replacing Clutch Linkages***
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 2

SERVICE CLUTCHES

III

OBJECTIVE 11B

Inspect, adjust, and replace cable type clutch linkage components.

INTRODUCTION

Cable type clutch linkages are found on small and medium size vehicles. Cable linkages on most newer vehicles are the self-adjusting type which are designed to automatically take up any slack in their cable, correcting their clutch pedal free travel. Even cable clutch linkages which are not self-adjusting have few parts and require little service.

Adjustment made to cable clutch linkages which do require adjustment ordinarily consists of loosening nuts or clips and pulling the cable tighter to bring clutch pedal free travel within specifications. Depending on the vehicle, such alterations are usually made near the clutch pedal or at the release fork. As with rod and lever linkages, cable linkages are manufactured in many different designs and no one procedure for their inspection, adjustment, and replacement will be useful. Use the vehicle's service manual, Supplement 5, "Guidelines for Inspecting, Adjusting, and Replacing Clutch Linkages," and the following special guidelines to complete this job sheet.

Special guidelines for adjusting cable type clutch linkages:

- Make sure the cable is installed in a smooth arc, free from kinks or bends.
- Check the cable to make sure no other wire, cable, or automotive component interferes with the clutch cable's smooth operation.
- Never yank on the cable—you can easily damage other parts of the linkage.
- The cable on a cable linkage is constructed of braided or twisted wires—make sure that no single strand of this cable has become broken inside the cable cover and is causing binding.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle with a cable type clutch linkage
- Supplement 5, ***Guidelines for Inspecting, Adjusting, and Replacing Clutch Linkages***
- Appropriate service manual
- Other equipment and materials as required by procedure.

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 3

SERVICE CLUTCHES

III

OBJECTIVE 11C

Inspect, adjust, repair, and replace hydraulic clutch components.

INTRODUCTION

Hydraulic clutch linkages have become the most common type of linkage because they are basically self-adjusting, are easily adaptable to different space limitations, and can transfer the motion from the clutch pedal to the release fork with little or no loss of power.

The power in a hydraulic linkage is transferred by the hydraulic fluid which is automatically kept at a constant level by the fluid reservoir on the master cylinder. Many hydraulic clutch linkages have no other method of adjusting clutch pedal free travel. However, hydraulic linkages that *can* be adjusted usually use a threaded adjusting nut to adjust either the push rod on the master cylinder or, more frequently, the slave cylinder push rod. (See Figure 12 in Objective 8 of the Information Sheet.)

Special guidelines for adjusting hydraulic type clutch linkages:

- Check the fluid reservoir for low fluid.
- Check the hydraulic lines for breaks, leaks, or kinks.
- Inspect the master cylinder and slave cylinder for worn seals, corrosion, and air in the system.
- The master cylinder and slave cylinder are often made of plastic—make sure they are mounted away from areas where they may become overheated.

BLEEDING THE HYDRAULIC CLUTCH LINKAGE

For a hydraulic system to work correctly, no air should be in the cylinders with the hydraulic fluid. Removing air from a clutch's hydraulic system is a process called ***bleeding the clutch***. Most hydraulic clutch linkages have special screws which allow the specialist to bleed the system. Check the vehicle service manual for the instructions applicable to the vehicle.

CAUTION
The brake fluid used as the fluid in a hydraulic clutch linkage will remove paint from the vehicle. Protect painted surfaces and wash off any spills immediately.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle with a hydraulic type clutch linkage
- Supplement 5, ***Guidelines for Inspecting, Adjusting, and Replacing Clutch Linkages***
- Appropriate service manual
- Other equipment and materials as required by procedure.

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

SERVICE CLUTCHES

OBJECTIVE 11D

Remove the transmission and clutch housing.

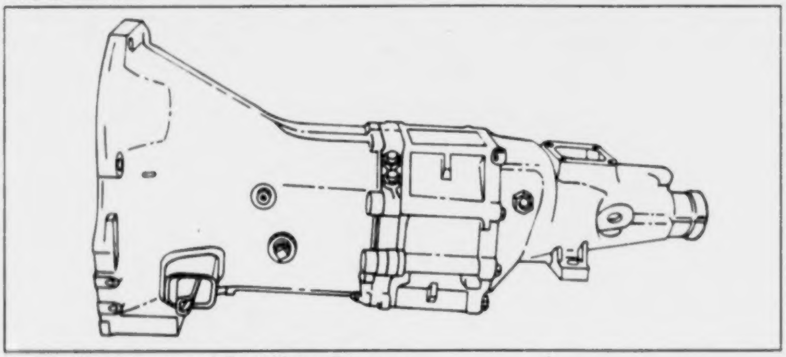
INTRODUCTION

Work on the clutch linkage does not usually require that the clutch pressure plate assembly, clutch disc, or release bearing mechanism be exposed. However when any of these clutch system components need service or repair, the specialist must gain access to these components through the clutch housing.

There are three ways to gain this access:

- The transmission housing and the clutch housing may be a single unit. Formerly found mostly on imports, this arrangement is currently the most common and popular because it eliminates the alignment problem between the clutch housing and the transmission housing. (Figure 1)

FIGURE 1



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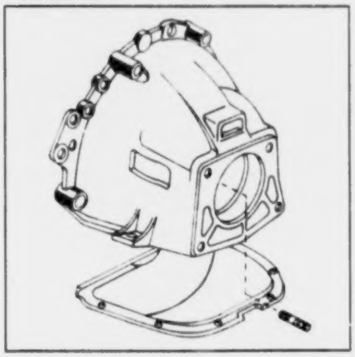
- The vehicle may have a metal inspection cover on the bottom of the clutch housing which can be unbolted to allow some types of inspections. (Figure 2) However if any components of the clutch assembly must be replaced, the transmission still must be removed because the transmission input shaft locks most components in place. Few vehicles have this type of access.

FIGURE 2



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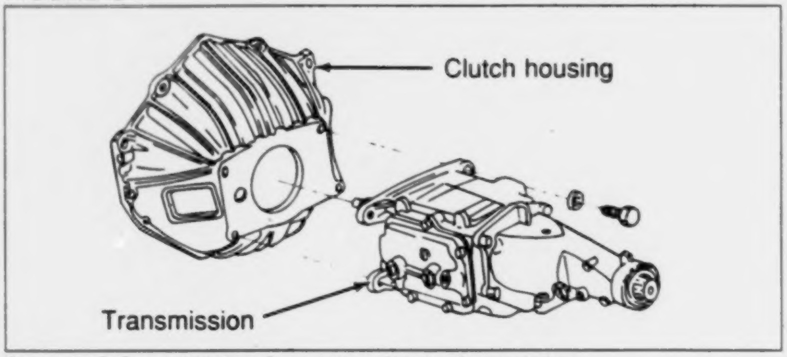
- The transmission housing and the clutch housing may be separate units—the transmission is removed first, and then the clutch housing is removed. (Figure 3) Formerly found on most domestic vehicles, this type of arrangement is currently found on older vehicles and some domestic models.

FIGURE 3



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NOTE: On some sports vehicles, the engine as well as the transmission and clutch must be removed whenever the transmission or clutch requires service or repair.

This job sheet describes the general procedures that will be necessary to remove the transmission and the clutch housing for the last type of access. However because of the wide range of possible transmission shift linkages, clutch linkages and other design features, it is critical that the vehicle's service manual be consulted at every step.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Job Sheet 3, Unit 1, ***Removing and Replacing the Driveline***
- Eye protection
- Fender covers
- Seat cover
- Shop light
- Combination wrenches
- Screwdrivers
- Hoist or jack stands
- Drain pan
- Pliers
- Mechanic's wire
- Masking tape and pen
- Engine support stand
- Wooden block
- Transmission jack & safety chains

- Socket wrench, sockets, and extensions
- Transmission dowels or clutch housing alignment pins
- Hoist stand

NOTE: The transmission and clutch housing are very heavy. You will need the help of an assistant to remove them.

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Remove the transmission

♦ WARNING ♦

Be sure the vehicle is cool enough to work on.

1. Raise the hood and place fender covers over the fenders.
2. Disconnect the battery cables, making sure to disconnect the **negative** cable first.

   ♦ WARNING ♦

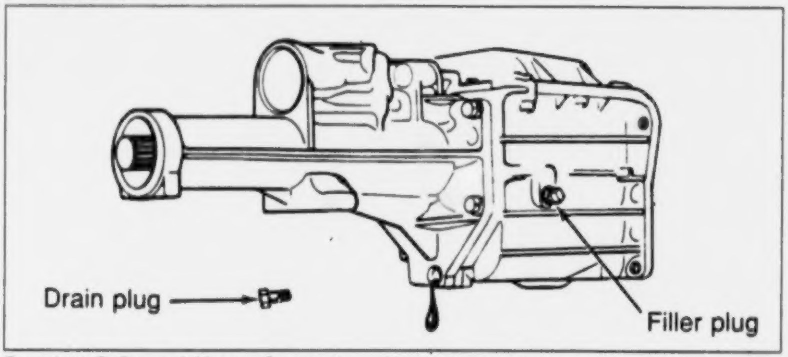
   Disconnecting the positive cable first can cause sparks which can cause the battery to explode.

3. Cover the front seat with a seat cover.
4. Shift the transmission into neutral.
5. Refer to the service manual to disconnect any part of the transmission shift linkage that must be disconnected inside the vehicle.
6. Raise the vehicle and support it safely on a hoist or jack stands.
7. If the manufacturer recommends that the transmission lubricant be drained when the transmission is removed, position a drain pan under the transmission drain plug and drain the transmission lubricant. (Figure 4)

   ♦ WARNING ♦

   Transmission lubricant can be **very** hot.

FIGURE 4



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8. Remove the drain pan.

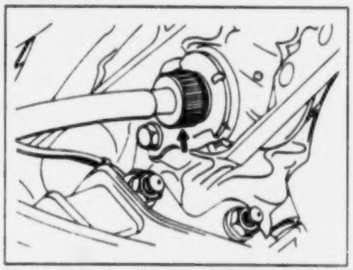
9. Inspect the transmission lubricant for flecks of metal. Gold-colored flecks are from synchronizer rings. Metal-colored flecks are from gears.

10. Use Job Sheet 3, Unit 1, to remove the driveline, plugging the rear end of the transmission housing if you have not removed the transmission lubricant.

11. Use pliers to loosen the collar on the speedometer cable from the transmission extension housing then pull the cable out of the transmission. (Figure 5)

    NOTE: Some speedometer cables are bolted on and will require a wrench to loosen.

FIGURE 5



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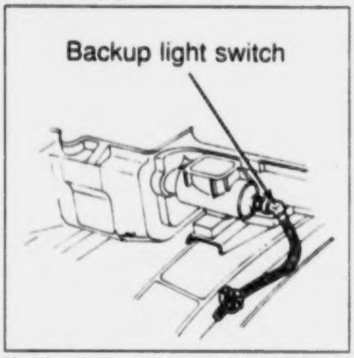
12. Label the cable with masking tape and use mechanic's wire to wire it out of the way.

13. If applicable, disconnect the backup light from the transmission. (Figure 6)

14. Label the wire with masking tape and use mechanic's wire to wire it out of the way.

FIGURE 6



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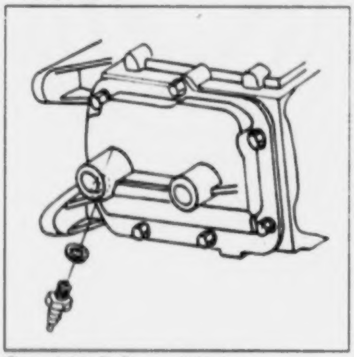
15. If there is a TCS (transmission-controlled spark) switch, disconnect the wires by pulling the wiring plug from the switch. (Figure 7)

16. Label the wire with masking tape and use mechanic's wire to wire it out of the way.

FIGURE 7



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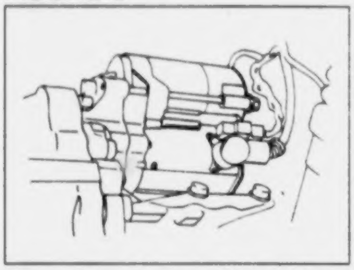
17. Remove the starter from the clutch housing and set it aside on a workbench. (Figure 8)

18. Refer to the service manual to disconnect the clutch linkage from the clutch housing, wiring parts out of the way. (See Job Sheet 1, 2, or 3.)

FIGURE 8



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19. Refer to the service manual to disconnect any part of the catalytic converter or exhaust system that may interfere with the removal of the transmission.

20. Use mechanic's wire to wire parts out of the way.

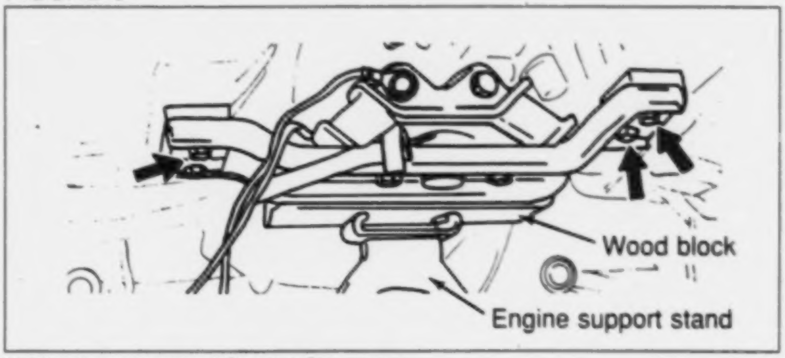
21. Refer to the service manual to disconnect the transmission shift linkage from the transmission, wiring parts out of the way.

22. If there is a clutch inspection cover, remove the bolts which hold the cover in place.

23. If the vehicle's manufacturer recommends that the engine be supported during transmission removal, place a wooden block on an engine support stand and position the support stand under the rear part of the engine oil pan. (Figure 9)

NOTE: The wooden block spreads the weight to avoid damage to the oil pan.

FIGURE 9



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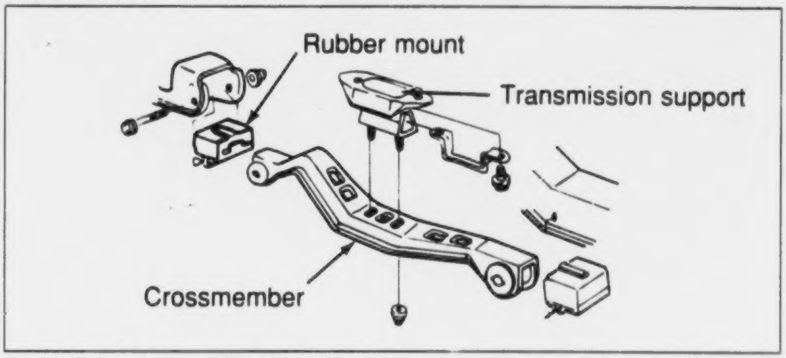
24. Raise the engine support stand slightly to take the weight of the engine off the transmission crossmember.

25. If the emergency brake cable linkage is connected to the transmission crossmember, disconnect it.

26. Unbolt the crossmember from the transmission and the chassis and remove it. (Figure 10)

FIGURE 10



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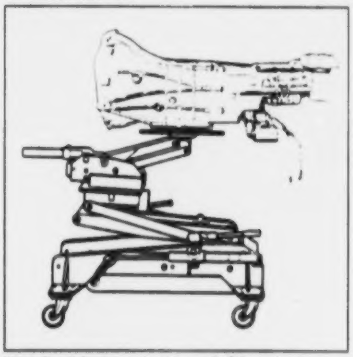
27. Position a transmission jack under the transmission. (Figure 11)

28. Secure the transmission to the transmission jack with safety chains.

29. Have your assistant help balance the transmission on the transmission jack as you remove the bolts which hold the transmission to the clutch housing.

FIGURE 11



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◆ WARNING ◆

The transmission is very heavy.

30. Use a combination wrench or a socket wrench with extensions to remove the large bolts which hold the top of the transmission to the top of the clutch housing.

31. Replace these bolts with transmission dowels or clutch housing alignment pins.

NOTE: Transmission dowels are several inches longer than the original bolts and will guide you in clearing the clutch housing with the transmission input shaft before you lower the transmission. This will keep you from accidently damaging the clutch assembly as you remove the transmission input shaft.

32. Remove the lower bolts which hold the transmission to the clutch housing.

33. Pull the transmission away from the clutch housing, pulling straight back and rocking the transmission from side to side if necessary until the transmission input shaft clears the clutch assembly.

34. Lower the transmission on the transmission jack and place it on a workbench.

PROCEDURE

Remove the clutch housing

1. Support the clutch housing on a hoist stand.

2. Have your assistant help support and balance the clutch housing on the jack stand as you remove the bolts which hold the clutch housing to the rear of the engine block.

3. Remove the clutch housing bolts and carefully remove the clutch housing.

4. Move the clutch housing to a workbench.

5. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 5

SERVICE CLUTCHES

III

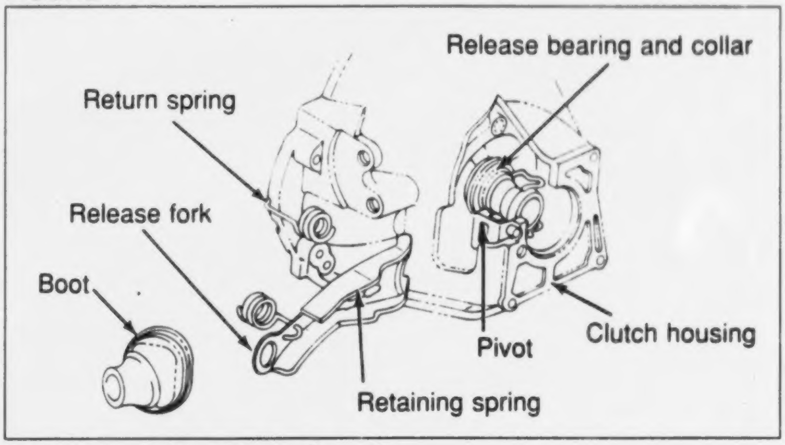
OBJECTIVE 11E

Remove, inspect, adjust, and replace the release bearing, release fork, and pivot.

INTRODUCTION

When the clutch housing is removed, the release bearing, release fork, and pivot remain installed in the clutch housing while the flywheel, pressure plate assembly, and clutch disc are attached to the engine crankshaft. These components should be carefully inspected during clutch service to determine whether they are a source of clutch problems. (Figure 1)

FIGURE 1



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Because the release bearing receives a lot of hard wear, it is cost effective to replace it during routine clutch inspection and service. The release bearing is relatively inexpensive and easy to replace once the area has been exposed.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 7, Unit 2, ***Removing and Replacing Pressed-On Bearings***
- Eye protection
- Screwdriver
- Replacement release bearing
- Replacement parts for other release mechanism components as needed
- Approved high-temperature lubricant

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be raised and supported safely, and the transmission and clutch housing should be removed from the vehicle. (Job Sheet 4)

PROCEDURE

Remove the release bearing and release fork

1. If there is a boot around the release fork, remove it. (You may have to remove the return springs first—see next step.)
2. Disconnect the return spring(s) from the release fork.
3. Consult the service manual and pry the release fork away from the pivot with a screwdriver, disconnecting any retaining springs, washers, or seals.
4. Refer to the service manual and disconnect the release bearing and collar from the release fork.

   NOTE: Notice whether the release bearing and collar fit firmly against the release fork—any looseness may indicate a worn part.

5. Be sure to retain any small parts such as clips, seals, washers, or springs.

PROCEDURE

Inspect the release bearing, release fork, and pivot

1. Examine the face of the release bearing that contacts the pressure plate assembly for excessive wear that would indicate that the release bearing is not disengaging completely from the pressure plate assembly when the clutch is engaged.
2. Holding the release bearing in the palm of your hand, press down slightly with the palm of your other hand and rotate it.

   NOTE: If the release bearing does not rotate smoothly and without noise, it may be the source of certain clutch problems.

3. Replace the release bearing whenever any routine work is done on the clutch, regardless of its apparent condition at the time of inspection.

4. Inspect the collar attached to the release bearing for wear or damage.

5. Inspect the release fork for cracks, warping, bending, wear or damage, particularly where it contacts the release bearing, at the pivot point, and at the linkage end.

6. Inspect the pivot for wear or damage, making sure it is tightly in place. Replace if needed.

7. Inspect the return spring(s) for wear, damage, or loss of flexibility.

8. Inspect the release fork's retainer spring, clips, bearing retainers, or other parts which hold the release bearing to the release fork.

9. Examine the release fork boot and any seals or washers for damage, wear, or loss of flexibility.

PROCEDURE

Adjust and replace the release bearing and release fork

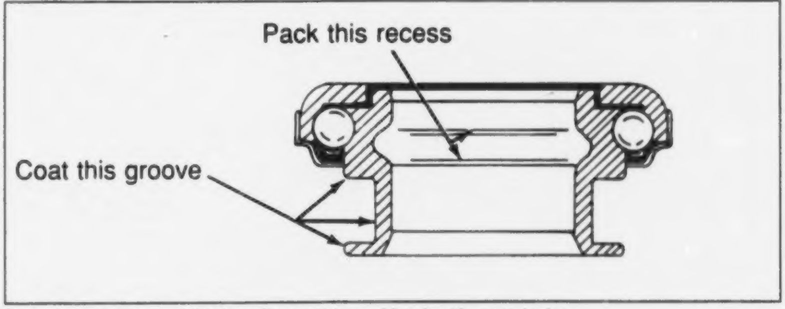
1. Press the new release bearing between the palms of your hands and rotate it to make sure it moves freely.

   NOTE: Before installing a new release bearing, compare the old bearing with the replacement to make sure they are identical.

2. If the release bearing collar is not replaced with the release bearing, use Supplement 7, Unit 2, to remove the old bearing and install the new bearing on the collar.

3. Fill the recessed groove inside the release bearing or its collar with an approved high temperature lubricant, bringing the lubricant level even with the inside bore diameter. (Figure 2)

FIGURE 2



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4. Put a thin film of approved, high-temperature lubricant on the release bearing collar where the release fork is installed and on the face of the release bearing which contacts the diaphragm spring or release levers.

   CAUTION

   Be sure not to get any lubricant on the clutch disc facings or this will cause the clutch to slip.

5. Replace any parts of the release mechanism that are worn or damaged.

6. Replace the release bearing on the release fork, making sure the parts fit together snugly.

7. Put a little of the approved lubricant on the pivot and reinstall the release fork on the pivot.

8. Adjust the release fork during installation to make sure the release bearing is centered around the transmission input shaft.

9. Reconnect the return spring(s) and replace the boot.

10. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB
SHEET 6

SERVICE CLUTCHES

III

OBJECTIVE 11F

Remove, inspect, and replace the pressure plate assembly and clutch disc.

INTRODUCTION

Of all the clutch system components, the ***clutch disc*** is the one most likely to wear out. When the clutch disc is damaged or worn or when the facings on the clutch disc wear thin, it should be replaced. If the clutch assembly is exposed for other service and the vehicle has gone over 50,000 miles, it is cost-effective to replace the clutch disc regardless of its condition.

The following are conditions which will cause the facings on the clutch disc to wear quickly:

- Operating the clutch in a partially engaged position—***riding the clutch***
- Weak pressure plate assembly spring(s)
- Too little clutch pedal free travel
- Fast starts
- Binding in the clutch linkage
- Overloading the engine
- Oil on the clutch disc facing

The facings on many clutch discs still contain asbestos. Strict safety precautions should be followed during service (See Unit 2, Supplement 9, "Asbestos".) and the clutch disc should be replaced, regardless of its condition, with one which does not contain asbestos.

If the clutch disc needs to be replaced because of wear or damage, it is usually recommended that the pressure plate assembly also be replaced. The only situation where *only* the clutch disc would be replaced is when the lubricant has contaminated the clutch disc. Check the vehicle's service manual if either component needs replacement. The pressure plate assembly itself may have wear and damage that requires its replacement. It should be carefully inspected as a part of clutch diagnosis or when the opportunity arises. If any part of either the clutch or the pressure plate assembly is defective, the entire component must be replaced. Individual parts are never repaired or replaced.

NOTE: When the pressure plate assembly is replaced, make sure the pressure plate and the release bearing match.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection

- Suitable cleaner for asbestos fibers
- Permanent marker or sharp awl
- Clutch alignment tool
- Soft-faced mallet
- Socket wrench and sockets
- Flywheel turner
- Workbench
- Depth micrometer or vernier caliper
- 0-1 in. (0-25 mm.) outside micrometer
- Shop towels
- Approved cleaning solvent
- Emery cloth
- Straightedge
- Set of feeler gauges
- Combination wrench
- Torque wrench
- Steel ruler or vernier caliper
- Thread-locking compound

NOTE: The clutch pressure plate assembly is heavy. You will need the help of an assistant to remove it.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle must be raised and supported safely, and the transmission and clutch housing must be removed. (Job Sheet 4)

PROCEDURE

Remove the clutch pressure plate assembly and clutch disc

1. Check the clutch housing and the area around the clutch pressure plate assembly for oil, metal, or pieces of clutch disc facing.

   NOTE: If there is evidence of an oil leak, check the following possible causes and correct the condition before replacing the pressure plate assembly and clutch disc:

   - Bad rear main bearing seal on the engine crankshaft
   - Leak from the camshaft plug
   - Overlubrication of the pilot bushing/bearing
   - Leaks around the flywheel mounting bolts
   - Bad transmission input shaft or seal
   - Clogged transmission vent

2. Use a suitable cleaner to clean the dust from the clutch pressure plate assembly and clutch disc. (See Unit 2, Supplement 9, "Asbestos.")

◆ WARNING ◆

Even though all clutch discs do not contain asbestos fibers, good safety practices require that the technician assume that asbestos fibers will be present.

3. Make matchmarks on the cover of the pressure plate assembly and the flywheel.

NOTE: Some flywheels have dowels which allow the pressure plate assembly to be installed in only one way.

4. Position a clutch alignment tool through the clutch disc inside the pressure plate assembly and tap it gently into the pilot bushing/bearing. (Figures 1 & 2)

FIGURE 1

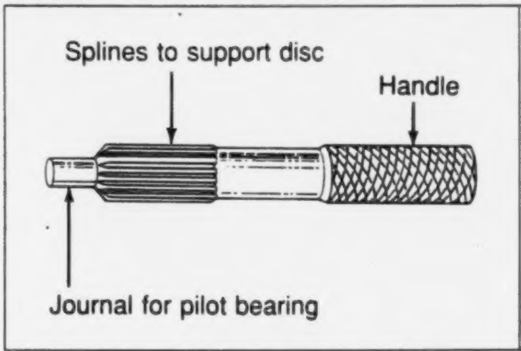

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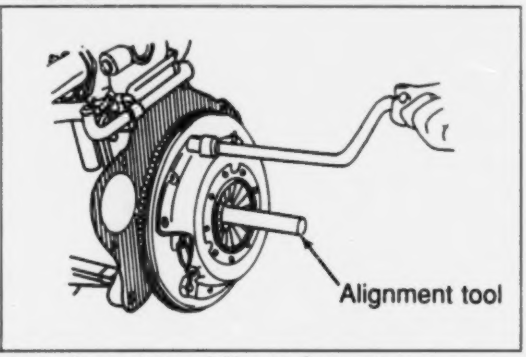
FIGURE 2



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◆ WARNING ◆

The pressure plate assembly is very heavy. The alignment tool will keep the pressure plate assembly from falling as the pressure plate mounting bolts are loosened. Check frequently to make sure the alignment tool is always tapped firmly in place as the bolts are removed.

5. Use a socket wrench to loosen each bolt only one or two turns at a time.

6. After loosening one bolt, loosen the bolt just opposite from it and proceed to each new bolt in a crisscross pattern until all the bolts are loosened.

CAUTION

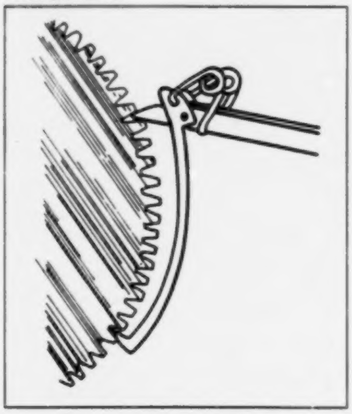
The spring(s) in the pressure plate assembly will push the pressure plate away from the flywheel. Loosening the bolts in an even, gradual manner will keep you from damaging the pressure plate assembly.

7. If you cannot reach a mounting bolt, use a flywheel turner to rotate the flywheel until you can reach it. (Figure 3)

8. Have your helper hold the pressure plate assembly securely as you remove the mounting bolts.

9. Remove the pressure plate assembly and place it on a workbench.

FIGURE 3



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PROCEDURE

Inspect the clutch disc

CAUTION

Do not touch the facings on the clutch disc. Any oil or grease on these facings will increase clutch slippage.

1. Remove the clutch disc and inspect it.

2. If any of the following conditions exist, replace the clutch disc:

   - Grease or oil on the clutch disc facings
   - Uneven wear on the disc facings
   - Damage or wear on the clutch disc hub or splines

   NOTE: If the splines on the clutch disc are more worn away from the axis than they are close to the axis, the condition is called ***bell-mouthing***. This is caused by misalignment of the engine and the transmission.

- Loose or broken torsional dampener springs

  NOTE: Some torsional dampener springs are designed to be slightly loose. Check your service manual.

- Loose, damaged, or missing rivets
- Damaged side plates
- Brown or bluish discoloration (an indication of heat damage)

3. Use a depth micrometer or a vernier caliper to measure the distance from a rivet to the top of the clutch lining.

4. If the distance is not at least 0.015 in. (0.38 mm.), replace the clutch disc.

5. Use an outside micrometer to measure the *total* thickness of the clutch lining in at least four places around the edge of the facing surface—the facing surface should have uniform wear over the entire surface.

6. If the total thickness is not at least 0.280 in. (7.11 mm.) for a clutch disc with either organic or metallic facings, replace the clutch disc.

   NOTE: If your measurements show that the facings are worn unevenly, check the flywheel and pressure plate for uneven wear. Also check the condition of the release bearing and make sure the transmission input shaft is free from grooves or ridges. Some of these parts may need to be replaced or repaired as well as replacing the clutch disc.

7. Put the old or replacement clutch disc on the transmission input shaft and spin it.

8. If the clutch disc wobbles or if the clutch disc splines do not fit smoothly onto the shaft, replace the clutch disc.

PROCEDURE

Inspect the clutch pressure plate assembly

CAUTION

All inspection procedures for the pressure plate assembly are performed without taking the assembly apart. Never remove any bolts or nuts that hold the assembly together.

1. Wipe the pressure plate assembly with a shop towel and an approved cleaning solvent.

2. Inspect the clutch pressure plate.

3. If any of the following conditions exist, replace the pressure plate assembly.

   - Deep grooves on the pressure plate surface

     NOTE: Shallow grooves can be polished out by a machinist.

   - Brown or bluish discoloration (an indication of heat damage)

   - Uneven wear on the pressure plate surface

     NOTE: If there is uneven wear, check the clutch disc and flywheel for uneven wear.

   - Excessive or uneven wear of the diaphragm spring fingers or release levers

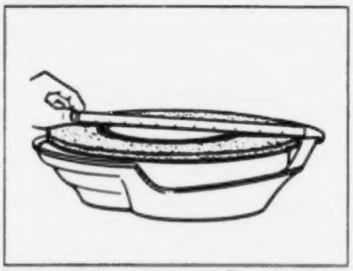
   - Cracks or damage

4. Examine the edges of the diaphragm spring fingers or the release levers—they should be worn evenly.

5. Place a straightedge across the surface of the pressure plate to check for warping. (Figure 4)

6. Slip feeler gauges between the straightedge and the surface of the pressure plate to determine the amount of warpage.

FIGURE 4



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7. Compare the thickness of the largest feeler gauge measurement to the manufacturer's specifications and replace the pressure plate if it is not within specifications.

8. Examine the face of the pressure plate; if it is worn to a high shine, use an emery cloth to polish out the shine.

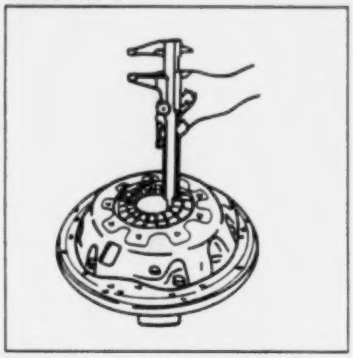
9. Place the pressure plate assembly, pressure plate down, on an even surface.

10. Depress the spring or levers several times to seat them.

11. Use a steel ruler or vernier caliper to measure the distance from the flat surface to the top of each finger of the diaphragm spring or the release levers—the distances should be equal. (Figure 5)

12. If the distances are unequal and the height of the release levers is adjustable, refer to the service manual and make adjustments.

FIGURE 5



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13. If the distances are unequal, and the levers are not adjustable, replace the pressure plate assembly.

14. Inspect the pressure plate assembly mounting bolts for damage and wear and replace them if necessary.

CAUTION

Be sure to replace these bolts with approved replacement bolts of hardened steel. Ordinary bolts will not hold under the stresses required of these parts.

PROCEDURE

Replace the clutch pressure plate assembly and clutch disc

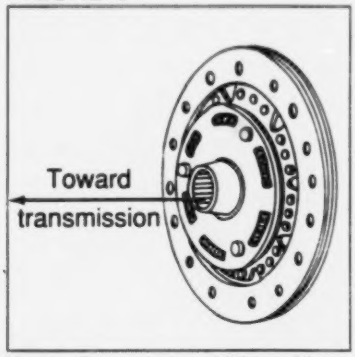
NOTE: Make sure all repair and replacement of other clutch assembly components is complete before replacing the clutch pressure plate assembly and clutch disc.

1. Place the clutch disc against the flywheel with the raised part **away** from the flywheel. (Figure 6)

CAUTION

Installing the clutch disc backwards is a common mistake that will often cause more damage than the original problem.

FIGURE 6



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2. Insert a clutch alignment tool through the clutch disc into the pilot bushing/bearing and tap it in place with a soft-faced mallet.
3. Align the matchmarks on the flywheel and pressure plate cover and place the pressure plate assembly over the clutch disc.
4. Have your assistant hold the pressure plate cover in place.
5. Put a thread-locking compound on the threads of the pressure plate mounting bolts.
6. Thread the pressure plate mounting bolts in place a few turns at a time, working in a crisscross pattern.
7. Use a combination wrench to tighten the mounting bolts evenly.

CAUTION

The pressure plate assembly can be distorted if these bolts are not tightened evenly and alternately.

8. Torque to specifications.
9. Remove the clutch alignment tool.
10. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 7

SERVICE CLUTCHES

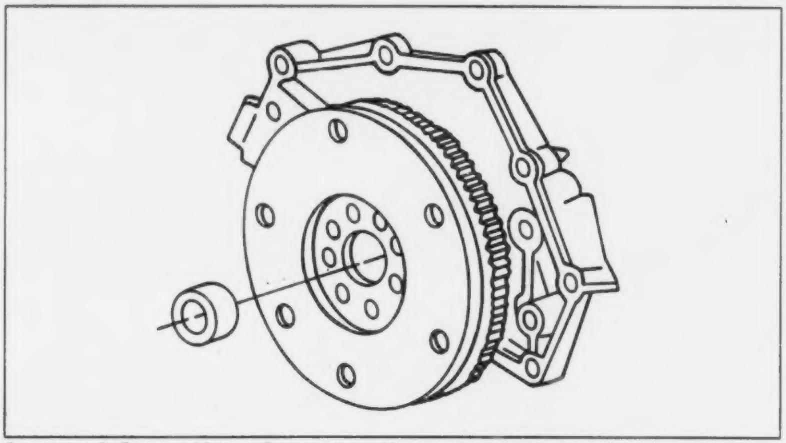
OBJECTIVE 11G

Remove, inspect, and replace the pilot bushing or bearing.

INTRODUCTION

Either a pilot bushing or a pilot bearing is press fit into the bore of the engine crankshaft to support the end of the transmission input shaft. The pilot bearing/bushing must always be in good condition so the transmission input shaft is adequately supported, correctly aligned, and can rotate freely. (Figure 1)

FIGURE 1



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Because of the heavy wear it receives, it is cost-effective to replace the pilot bushing or bearing whenever any clutch service is performed. Inspecting the bushing or bearing after it is removed may help you diagnose a bad bushing/bearing as the cause of certain noise or performance problems, but a bushing or bearing should always be replaced by a new one, even if it appears to be in good condition.

NOTE: A very few manual transmission vehicles do not have a pilot bushing/bearing—the input shaft simply rests in a hole in the crankshaft. Refer to the service manual if you do not find this part.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Shop towels
- Pilot bearing puller
- Approved cleaning solvent
- Bristle brush
- Replacement pilot bushing or bearing

- Clutch alignment tool or pusher/bearing installer
- Soft-faced mallet
- Approved high-temperature lubricant

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle must be raised and supported safely, and the transmission and clutch housing must be removed. (Job Sheet 4) The pressure plate assembly and the clutch disc must be removed. (Job Sheet 6) The flywheel can either be on or off the engine block.

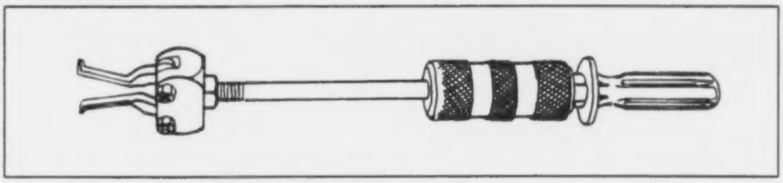
PROCEDURE

Remove, inspect, and replace the pilot bushing or bearing

1. Clean any excess grease out of the pilot bushing or bearing.

2. Use a pilot bearing puller to remove the pilot bearing or bushing. (Figure 2)

FIGURE 2



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NOTE: An alternate method to remove a pilot bushing is to fill the crankshaft bore with heavy chassis grease and then tap a clutch alignment tool into the hole with a soft-faced mallet. The pressure of the compacting grease should force the bushing or bearing out.

3. Examine the bushing or bearing for wear or damage. (To examine a bearing, use Unit 2, Supplement 6 or 8 on bearing damage diagnosis.)

4. Clean the crankshaft bore using shop towels, a bristle brush, and an approved cleaning solvent.

5. Dry the bore with a shop towel.

6. Lubricate the replacement pilot bushing or bearing according to manufacturer's specifications.

7. Position the bearing or bushing on a clutch alignment tool squarely in line with the crankshaft bore.

8. Use a soft-faced mallet to gently tap on the clutch alignment tool or the pusher/bearing installer, seating the pilot bushing or bearing in place.

9. After it is installed, coat the bearing or bushing with an approved high temperature lubricant.

CAUTION

Avoid overlubrication. Lubricant that gets on the clutch disc can cause the clutch to slip.

10. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 8

SERVICE CLUTCHES

OBJECTIVE 11H

Inspect, remove, repair, service, and replace the flywheel and ring gear.

INTRODUCTION

The flywheel should be routinely inspected when any work is done on the clutch assembly. If the flywheel has deep grooves, cracks, or heat damage it must be replaced. However if there are shallow grooves or uneven wear, it is most cost effective to have the flywheel repaired. If the ring gear on the flywheel is worn or damaged, it will have to be removed and a new ring gear installed. All of these problems require that the flywheel be removed from the vehicle. Flywheel and ring gear repair is usually done by an automotive machinist or a clutch specialist.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Shop light
- Approved cleaning solvent
- Shop towels
- Emery cloth
- Drift punch and hammer or vise grip pliers
- Replacement dowels, if needed
- Soft-faced mallet
- Flywheel turner
- Vise grip pliers, if needed
- Replacement flywheel mounting bolts, if needed
- Replacement flywheel dowels, if needed
- Thread-locking compound
- Sockets and socket wrench
- Torque wrench
- Sharp awl or permanent marker, if needed

NOTE: The flywheel is extremely heavy. You will need the help of an assistant to remove it.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle must be raised and supported safely, and the transmission and clutch housing must be removed. (Job Sheet 4) The pressure plate assembly and clutch disc must also be removed. (Job Sheet 6)

PROCEDURE

Inspect and repair the flywheel and ring gear

1. Position a shop light so you can check the flywheel surface for lubrication leaks that will have to be fixed:

   - Leak from the rear main bearing seal on the engine crankshaft
   - Leak from the camshaft plug
   - Overlubrication of the pilot bushing/bearing
   - Leaks around the flywheel mounting bolts
   - Bad transmission input shaft or seal
   - Clogged transmission vent

2. Use a shop towel and approved cleaning solvent to clean the flywheel and ring gear.

3. Notice any black, brown, or bluish discoloration on the flywheel; this is an indication of heat damage—the flywheel must be replaced.

4. Check the flywheel surface for cracks, grooves, wear, or damage.

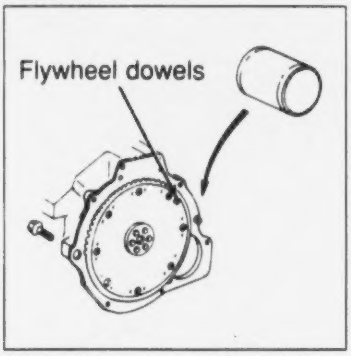
5. Check the vehicle's service manual and replace the flywheel if the cracks, grooves, or runout exceeds manufacturer's specifications.

   NOTE: An automotive machinist or clutch specialist can sometimes correct flywheel grooves and uneven wear by special grinding followed by rebalancing the flywheel.

6. Examine the face of the flywheel; if it is worn to a high shine, use an emery cloth to polish out the shine.

7. If the flywheel uses dowels to help attach the pressure plate assembly, examine the dowels and replace any that are damaged, worn, loose, or missing. (Figure 1)

FIGURE 1



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NOTE: Dowels in holes that are drilled all the way through the flywheel can be driven out with a drift punch and hammer. Dowels in blind holes that don't go all the way through the flywheel must be pulled out with vise grip pliers. **Never** reuse old dowels that have been removed—replace them with new ones. Tap replacement dowels into the hole with a soft-faced mallet.

8. Examine the teeth on the flywheel ring gear, using a flywheel turner to rotate the flywheel.

   NOTE: If the flywheel ring gear teeth are worn or damaged, the ring gear will have to be replaced by an automotive machinist or clutch specialist.

9. Use Job Sheet 10 to measure flywheel runout. If it is not within specifications, have the flywheel repaired or replace it.

PROCEDURE

Remove the flywheel and ring gear

1. Have an assistant help you hold the flywheel while it is being removed.

2. If necessary, make matchmarks on the flywheel and the crankshaft flange so that the flywheel can be reinstalled in the identical position.

   NOTE: Most flywheel mounting bolts are positioned so that the flywheel can only be installed in one way.

3. Use a socket wrench to loosen the flywheel mounting bolts a little at a time, moving from bolt to bolt in a crisscross pattern.

4. Have your assistant hold the flywheel while you remove the flywheel mounting bolts.

5. Remove the flywheel from the crankshaft flange.

6. Inspect the flywheel mounting bolts and replace any that are worn or damaged.

   CAUTION

   Be sure to replace these bolts with approved replacement bolts of hardened steel. Ordinary bolts will not hold under the stresses required of these parts.

7. Clean and inspect the surface of the crankshaft flange, removing any nicks or burrs with an emery cloth.

PROCEDURE

Replace the flywheel and ring gear

1. Inspect the flywheel to make sure the automotive machinist or clutch specialist has made the needed repairs.

2. Have an assistant help you hold the flywheel to the crankshaft flange during reinstallation.

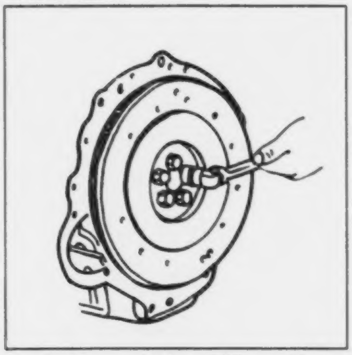
3. Put a thread-locking compound on the threads of the flywheel mounting bolts.

4. Use a socket wrench to tighten the flywheel mounting bolts a little at a time, moving from bolt to bolt in a crisscross pattern. (Figure 2)

5. Torque the mounting bolts to the manufacturer's specifications.

6. Use Job Sheet 10 to remeasure flywheel runout, making sure it is within specifications.

FIGURE 2



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7. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 9

SERVICE CLUTCHES

OBJECTIVE 11I

Measure crankshaft end play and flywheel runout.

INTRODUCTION

For the clutch to function properly, the clutch disc must be clamped securely between the flywheel and the pressure plate. When the surface of the flywheel is not even, a condition called ***flywheel runout***, the clutch can slip, causing excessive wear and damage to other clutch components. This can eventually lead to clutch failure. Flywheel runout should be checked as a part of clutch inspection, particularly if there are signs of uneven flywheel wear or clutch slippage.

If the engine crankshaft moves in and out too much, ***crankshaft end play***, the flywheel attached to the crankshaft flange will not clamp the clutch disc securely, again causing clutch slippage and clutch wear and failure. When the technician evaluates clutch operation, both flywheel runout and crankshaft end play should be measured to make sure they are within acceptable limits. Flywheel runout can be corrected by repair or replacement of the flywheel, but the correction of excessive crankshaft end play requires additional evaluation and service which is best handled by a technician trained in engine repair.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Unit 1, Supplement 8, ***Using a Dial Indicator***
- Job Sheet 8, ***Inspect, remove, repair, service, and replace the flywheel and ring gear***.
- Eye protection
- Approved cleaning solvent
- Bristle brush
- Shop towels
- Sockets and socket wrench
- Torque wrench
- Dial indicator
- Flywheel turner

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle must be raised and supported safely, and the transmission and clutch housing must be removed. (Job Sheet 4) The pressure plate assembly, clutch disc (Job Sheet 6), and flywheel (Job Sheet 8) must be removed.

PROCEDURE

Measure crankshaft end play

1. Use an approved cleaning solvent, bristle brush, and shop towels to clean and dry the crankshaft flange.
2. Pressing on the crankshaft flange, push the crankshaft as far towards the front of the vehicle as it will go.
3. Mount a dial indicator on the engine block with its plunger at a 90° angle to the face of the crankshaft flange.
4. Use the procedures in Unit 1, Supplement 8, "Using a Dial Indicator," to measure crankshaft end play.
5. Push on the harmonic balancer on the other end of the crankshaft, moving the crankshaft as far towards the open clutch area as it will go.

   NOTE: If you have any difficulty finding the harmonic balancer, have your instructor show you its location on the vehicle you are using.

6. Measure the amount of end play that registers on the dial indicator.
7. Compare this measurement to manufacturer's specifications.
8. If the measurement exceeds specifications, make arrangements to bring the crankshaft end play within acceptable limits.

   NOTE: If crankshaft end play is not within specifications, flywheel runout measurement will not be accurate.

PROCEDURE

Measure flywheel runout

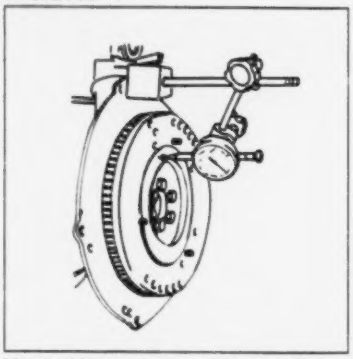
1. Follow the procedures outlined in Job Sheet 8 to replace the flywheel and ring gear on the crankshaft flange.
2. Make sure the flywheel's friction surface and mounting bolts are clean and dry.

3. Mount a dial indicator on the engine block with its plunger at a 90° angle to the part of the flywheel face that contacts the pressure plate. (Figure 1)

4. Use a flywheel turner to rotate the flywheel for the runout check.

5. Use the procedures in Unit 1, Supplement 8, "Using a Dial Indicator," to measure flywheel runout.

FIGURE 1



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6. Compare the runout measurement to manufacturer's specifications.

7. If runout is slightly excessive, have an automotive machinist or a clutch specialist resurface the flywheel.

8. If there is significant flywheel runout, the flywheel will have to be replaced.

9. Always recheck flywheel runout when installing a new flywheel or reinstalling an old flywheel that has been repaired.

10. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 10

SERVICE CLUTCHES

III

OBJECTIVE 11J

Inspect the engine block, clutch housing, and transmission housing mating surfaces.

INTRODUCTION

Sometimes clutch and transmission problems are caused by the misalignment of the engine block, clutch housing, and transmission. Some problems that may indicate such misalignment are:

- Transmission jumping out of gear (especially third or fourth)
- Excessive wear of transmission gears
- Excessive clutch disc spin-down time
- Vibration in the clutch pedal or driveline
- Rough clutch pedal action
- Noise from the pilot or release bearing
- Excessive wear of the pilot bushing/bearing
- Bell-mouthing of the clutch disc hub

The first step in checking the engine block, clutch housing, and transmission alignment is to inspect the mating surfaces of these components. To avoid some misalignment problems, many newer vehicles combine the clutch housing and the transmission housing into a single unit. The procedures in this job sheet should be adjusted to include only the mating components in such vehicles.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Bristle brush
- Shop towels
- Approved cleaning solvent
- Emery cloth
- Mill file

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle must be raised and supported safely, and the clutch housing/transmission must be removed. (Job Sheet 4) The release bearing assembly and the release fork should be removed. (Job Sheet 5) The clutch disc and pressure plate assembly should be removed from the flywheel (Job Sheet 6), and the flywheel should be removed from the crankshaft flange (Job Sheet 8).

PROCEDURE

Inspect the engine block, clutch housing, and transmission housing mating surfaces

1. Check the engine block, clutch housing, and transmission mating surface for signs of lubrication leaks that will need to be fixed:

    - Bad rear main bearing seal on the engine crankshaft
    - Leak from the camshaft plug
    - Overlubrication of the pilot bushing/bearing
    - Leaks around the flywheel mounting bolts
    - Bad transmission input shaft or seal
    - Clogged transmission vent

2. Use a bristle brush, approved cleaning solvent, and shop cloths to clean and dry the following surfaces:

    - The front and rear mating surfaces of the clutch housing
    - The clutch housing bore
    - The rear mounting surface of the engine block and crankshaft
    - The front mounting surface of the transmission housing

    NOTE: Dirty or rusted surfaces can cause warping.

3. Inspect the surfaces and remove nicks, burrs, paint, or other foreign material from the surfaces with an emery cloth or mill file.

    CAUTION

    Make sure that you do not smooth or file the surfaces too much or runout measurements will increase.

4. Check and clean clogged vents in the clutch housing.

5. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 11

SERVICE CLUTCHES

III

OBJECTIVE 11K

Measure clutch housing face runout and clutch housing bore runout.

INTRODUCTION

As mentioned in Job Sheet 9, a number of clutch problems can be caused by the improper alignment of the engine block, clutch housing, and transmission housing. Naturally, questions about proper alignment only arise in vehicles with a *separate* engine block, clutch housing, and transmission. In those vehicles having a clutch housing and transmission which are a single unit, the chances of misalignment are greatly reduced. The measurements made in this Job Sheet are not possible for those vehicles.

Measuring the ***clutch housing face runout*** will tell you whether the clutch housing surface which aligns with the transmission is warped. Measuring ***clutch housing bore runout*** will determine whether the transmission input shaft is centered in the clutch housing bore. If either of these runout measurements are outside specifications, the engine block, clutch housing, and transmission housing are not aligned and the problems listed in Job Sheet 9 could occur.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Supplement 8, Unit 1, ***Using a Dial Indicator***
- Eye protection
- Clutch alignment tool and attachments
- Masking tape
- Dial indicator and attachments
- Small mirror
- Socket wrench and sockets
- Pencil and paper
- Rubber band

NOTE: You will need an assistant to rotate the crankshaft while you take the runout readings.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle must be raised and supported safely, and the transmission must be removed. (Job Sheet 4) The flywheel should be installed on the crankshaft flange (Job Sheet 8), and the clutch disc and pressure plate assembly should be installed. (Job Sheet 6) The engine block and clutch housing mating surfaces should be cleaned and inspected (Job Sheet 9), and the clutch housing, but not the transmission, should be installed (Job Sheet 12).

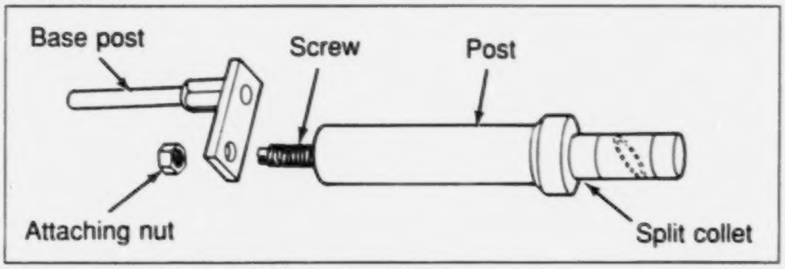
PROCEDURE

Measure clutch housing face runout

1. Assemble the clutch alignment tool.

2. Put a short piece of masking tape half way around the split collet on the clutch alignment tool to hold it until it is inserted in the clutch disc. (Figure 1)

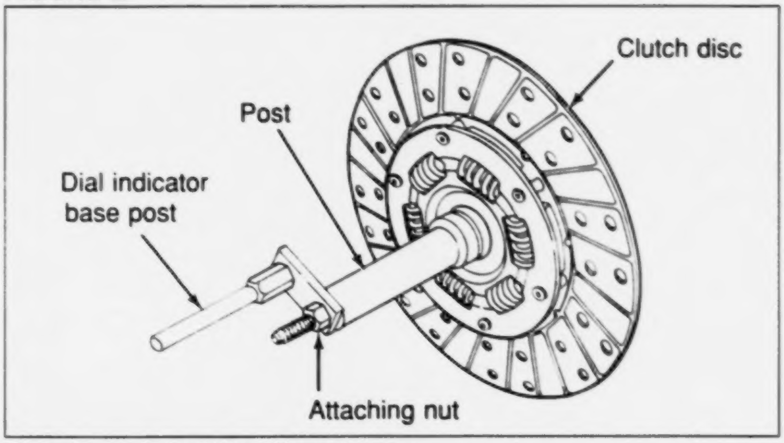
FIGURE 1


Base post
Screw
Post
Attaching nut
Split collet

Used with permission of Ford Motor Company.

3. Insert the collet on the alignment tool through the clutch housing bore, the pressure plate assembly, and the clutch disc into the pilot bushing or bearing. (Figure 2) (The pressure plate assembly is not visible in Figure 2.)

FIGURE 2


Clutch disc
Post
Dial indicator
base post
Attaching nut

Used with permission of Ford Motor Company.

4. Using a socket wrench, turn the attaching nut on the clutch alignment tool until the alignment tool is held *absolutely immovable* in the pilot bushing/bearing.

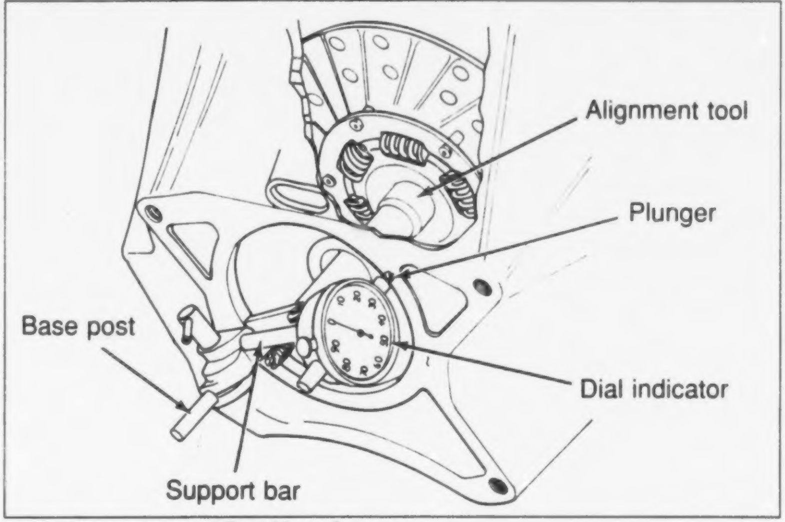
   NOTE: Any movement in the alignment tool will cause it to give an inaccurate reading.

5. Try to move the alignment tool base post up and down or back and forth—if there is any movement at all, tighten the attaching nut tighter.

6. Use the attachments for the dial indicator to install it on the base post of the clutch alignment tool.

7. Position the plunger of the dial indicator at a 90° angle to the face of the clutch housing just outside the clutch housing bore. (Figure 3)

FIGURE 3



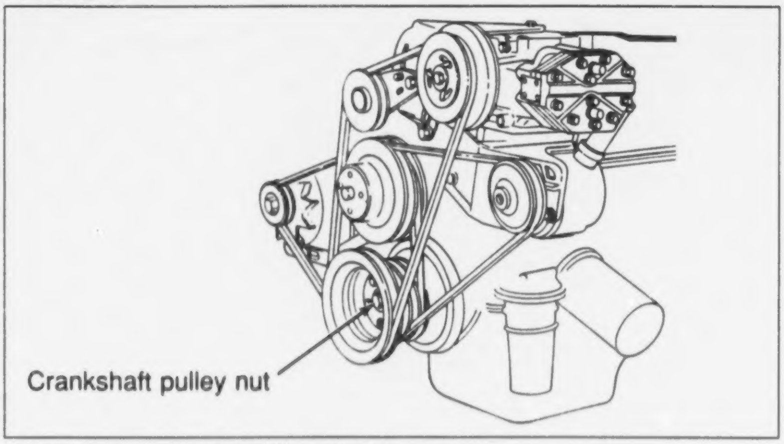
Used with permission of Ford Motor Company.

8. Remove all of the spark plugs from the engine block to make rotating the crankshaft easier.

9. Have your assistant place a socket wrench on the crankshaft pulley nut and rotate the crankshaft, moving the dial indicator around the circumference of the clutch housing face one rotation. (Figure 4)

10. Use Supplement 8, Unit 1, "Using a Dial Indicator," to measure clutch housing face runout.

FIGURE 4



Used with permission of Ford Motor Company.

11. Use a small mirror to read the pointer of the dial indicator as it rotates around the face of the clutch housing.
12. Repeat the runout check to verify your reading.
13. Compare your clutch housing face runout reading with manufacturer's specifications.
14. If the face runout is not within specifications, loosen the clutch alignment tool and reposition it in the pilot bearing, making sure it is accurately positioned.
15. Recheck the runout measurement.
16. If the runout reading is still not within specifications, loosen the bolts securing the clutch housing to the engine block, readjust the housing on the bolts, and retorque the bolts to specification.
17. Recheck the runout measurement.
18. If this does not correct the runout, replace the clutch housing.

PROCEDURE

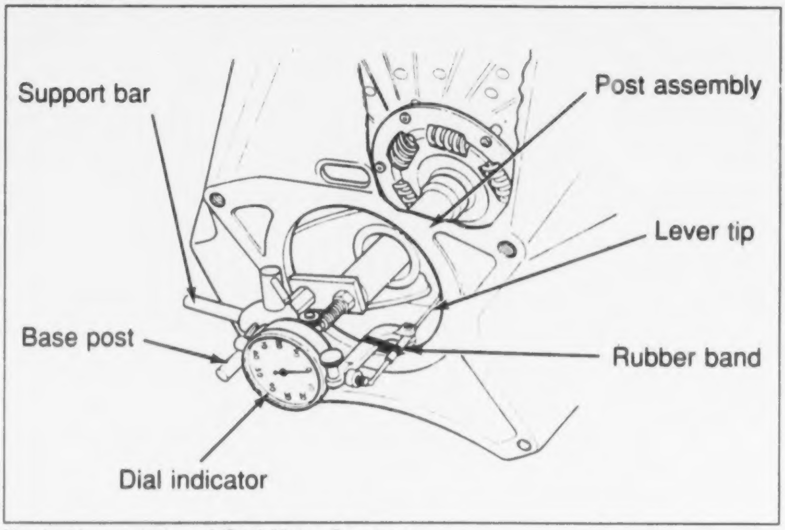
Measure clutch housing bore runout

1. Equip the dial indicator plunger with a lever attachment tool.
2. Wrap a rubber band lightly around the lever attachment (Figure 5) to preload the plunger.

   NOTE: Don't wrap the rubber band too tightly or you will get an inaccurate reading.

3. Position the tip of the lever attachment at a 90° angle against the *inside* of the clutch housing bore. (Figure 5)

FIGURE 5



Used with permission of Ford Motor Company.

4. Use Supplement 8, Unit 1, "Using a Dial Indicator," to measure clutch housing bore runout.

5. Have your assistant place a socket wrench on the crankshaft pulley nut and rotate the crankshaft, moving the dial indicator around the circumference of the clutch housing bore one rotation.

6. Use a small mirror to read the pointer of the dial indicator as it rotates around the bore of the clutch housing.

7. Repeat the runout check to verify your reading.

8. Compare your clutch housing bore runout reading with manufacturer's specifications.

9. If the bore runout is not within specifications, loosen the clutch alignment tool and reposition it in the pilot bearing, making sure it is accurately positioned.

10. Recheck the runout measurement.

11. If the runout reading is still not within specifications, loosen the bolts securing the clutch housing to the engine block, readjust the housing on the bolts, and retorque the bolts to specification.

12. Recheck the runout measurement.

13. If this does not correct the runout, replace the clutch housing.

14. Clean work area and return equipment and materials to proper storage or proceed to next job sheet as directed by your instructor.

JOB SHEET 12 — SERVICE CLUTCHES — III

OBJECTIVE 11L

Replace the clutch housing and transmission.

INTRODUCTION

When clutch and transmission service and repair is complete, the clutch housing and transmission are reinstalled in the vehicle. The process reverses the removal process, but a special effort must be made not to damage any of the parts as they are replaced.

The following is a checklist of tasks which should be completed before the clutch housing and transmission are replaced:

- The engine block, clutch housing, and transmission housing mating surfaces should be cleaned and inspected. (Job Sheet 10)
- The release bearing, release fork, and pivot should be reinstalled in the clutch housing. (Job Sheet 5)
- Crankshaft end play should be checked. (Job Sheet 9)
- The flywheel and ring gear should be reinstalled. (Job Sheet 8)
- Flywheel runout should be rechecked. (Job Sheet 9)
- A new pilot bushing/bearing should be installed. (Job Sheet 7)
- The pressure plate assembly and clutch disc should be replaced. (Job Sheet 6)

This job sheet describes the general procedures necessary to replace the clutch housing and transmission for a vehicle on which these two housings are separate units. Because of the wide range of possible transmission shift linkages, clutch linkages, and other design features, it is critical that the vehicle's service manual be consulted at every step.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Job Sheet 3, Unit 1, ***Removing and Replacing the Driveline***
- Job Sheet 11, ***Measure Clutch Housing Face Runout and Clutch Housing Bore Runout***
- Eye protection
- Shop light
- Hoist stand
- Torque wrench
- Transmission jack and safety chains
- Approved high temperature lubricant
- Transmission dowels or clutch housing alignment pins
- Socket wrench, sockets, and extensions
- Combination wrenches
- Screwdrivers

- Pliers
- Drain pan
- Approved transmission lubricant
- Lube gun

NOTE: The transmission and clutch housing are very heavy. You will need the help of an assistant to replace them.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The clutch housing and transmission should be off the vehicle. (Job Sheet 4) The vehicle should be raised, and if recommended by the manufacturer, the engine should be supported by an engine support. The tasks listed in the introductory material should be completed.

PROCEDURE

Replace the clutch housing

1. Position a hoist stand below and in front of the flywheel to hold the clutch housing while it is being replaced.
2. Have an assistant help you lift the clutch housing onto the hoist stand.
3. Use the hoist stand to raise the clutch housing to the engine block.
4. Align the bolt holes on the clutch housing and the engine block.
5. Adjust the hoist stand to support the clutch housing while you install the housing bolts by hand.
6. Torque the bolts to manufacturer's specifications, using a crisscross pattern.

   NOTE: Aluminum clutch housings are very soft. Use flat washers under the heads of all nuts and bolts.
7. Remove the hoist stand.
8. Use Job Sheet 11 to measure the clutch housing face runout and bore runout.

PROCEDURE

Replace the transmission

1. Support the transmission on a transmission jack and secure it with safety chains.

2. Make sure the transmission input shaft is clean and in good condition.

3. Put a light film of approved high temperature lubricant on the transmission input shaft.

CAUTION

If you use too much lubricant, it may contaminate the clutch disc causing the clutch to slip.

4. Push one of the shifting arms on the transmission into a gear instead of neutral.

5. Place clutch housing alignment pins in the top two bolt holes on the clutch housing.

6. Use the transmission jack to lift the transmission into place.

7. Move the top bolt holes on the transmission onto the alignment pins, centering the transmission input shaft at the pressure plate assembly.

CAUTION

Make sure the alignment pins are in the transmission bolt holes **before** the transmission input shaft contacts the pressure plate assembly and clutch disc.

8. Carefully move the transmission towards the clutch housing, moving the transmission input shaft into the splines of the clutch disc.

9. Turn the output shaft at the rear of the transmission slightly to help the input shaft splines mesh with the splines in the hub of the clutch disc.

CAUTION

Do not force the input shaft into the clutch disc. If it does not slip in smoothly, rotate the output shaft or move the transmission back to determine any obstruction.

10. Push the transmission housing flush with the clutch housing.

CAUTION

Never allow the transmission to hang in the clutch housing on the transmission input shaft, or it will warp the clutch disc.

11. Insert and tighten the bottom housing bolts with a socket wrench and extension.

    NOTE: Be sure to use the original housing bolts or replace them if necessary with approved replacement bolts of special hardened steel.

12. Remove the alignment pins one at a time, replacing them with housing bolts.

13. Working in a crisscross pattern, torque the bolts to specifications.

14. Replace the transmission crossmember and install the crossmember bolts.

    NOTE: Make sure any necessary washers are in place.

15. Torque the crossmember bolts to specifications.

16. Unchain and remove the transmission jack from the transmission.

17. If the engine was supported on an engine support stand, lower the support stand and remove it.

18. If the emergency brake cable linkage should be connected to the transmission crossmember, reconnect it.

    NOTE: As you reconnect this cable and other wires, remove the holding wires and masking tape used to tag the parts and remove them from the working area.

19. If there is a clutch inspection cover, replace it, torquing the bolts to specifications.

20. Consult the appropriate service manual and reconnect the shift linkages to the transmission.

21. Reconnect any part of the catalytic converter or exhaust system that was moved or removed to allow the transmission to be removed.

22. Consult the vehicle service manual and reconnect the clutch linkages to the clutch housing.

23. Reinstall the starter.

24. If a TCS (transmission-controlled spark) switch has been disconnected, reconnect it.

25. If there is a backup light connection to the transmission, reconnect it.

    NOTE: Replace the ring seal if equipped.

26. Reconnect the speedometer cable, tightening the collar with pliers.
27. Refer to the service manual and reconnect the transmission shift linkages.
28. Shift the transmission into every gear to make sure the adjustment is correct.
29. Shift the transmission into neutral.
30. Use Job Sheet 3, Unit 1, to replace the driveline.
31. Make sure the transmission drain plug is tightly in place.
32. Position a drain pan under the transmission filler plug.
33. Remove the filler plug and use a lube gun to fill the transmission with approved lubricant.

    NOTE: The lubricant should reach just below the filler plug opening.

34. Replace and tighten the transmission filler plug.
35. Lower the vehicle.
36. Reconnect the battery.
37. Road test the vehicle.
38. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PRACTICAL TESTS

SERVICE CLUTCHES III

JOB SHEET 1

Inspect, adjust, and replace rod and lever type clutch linkage components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Properly prepared the vehicle.	_____	_____
4. Measured clutch pedal free travel according to vehicle manufacturer's recommendations.	_____	_____
5. Followed the guidelines in Supplement 5 to inspect the parts of the clutch linkage, replacing any missing, worn, or damaged parts.	_____	_____
6. Adjusted the clutch linkage following procedures outlined in the service manual.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Inspect, adjust, and replace cable type clutch linkage components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Properly prepared the vehicle.	_____	_____
4. Measured clutch pedal free travel according to vehicle manufacturer's recommendations.	_____	_____
5. Followed the guidelines in Supplement 5 to inspect the parts of the clutch linkage, replacing any missing, worn, or damaged parts.	_____	_____
6. Adjusted the clutch linkage following procedures outlined in the service manual.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 3

Inspect, adjust, repair, and replace hydraulic clutch components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Properly prepared the vehicle.	_____	_____
4. Measured clutch pedal free travel according to vehicle manufacturer's recommendations.	_____	_____
5. Followed the guidelines in Supplement 5 to inspect the parts of the clutch linkage, replacing any missing, worn, or damaged parts.	_____	_____
6. If required, adjusted the clutch linkage following procedures outlined in the service manual.	_____	_____
7. Bled the hydraulic clutch linkage following procedures outlined in the service manual.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Remove the transmission and clutch housing.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Prepared the transmission and clutch housing for removal following outlined procedures.	_____	_____
4. Supported the engine and transmission properly prior to removing the transmission crossmember.	_____	_____
5. Removed the transmission crossmember correctly.	_____	_____
6. Removed the transmission following outlined procedures.	_____	_____
7. If required, removed the clutch housing following outlined procedures.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 5

Remove, inspect, adjust, and replace the release bearing, release fork, and pivot.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Removed the release mechanism parts following outlined procedures.	_____	_____
4. Inspected the release mechanism parts correctly.	_____	_____
5. Adjusted and replaced the release mechanism parts following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Remove, inspect, and replace the pressure plate assembly and clutch disc.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected clutch housing and pressure plate assembly for lubricant leaks.	_____	_____
3. Removed pressure plate assembly and clutch disc following outlined procedures.	_____	_____
4. Inspected pressure plate assembly correctly.	_____	_____
5. Inspected clutch disc correctly.	_____	_____
6. Replaced the pressure plate assembly and clutch disc following outlined procedures.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE CLUTCHES

JOB SHEET 7

Remove, inspect, and replace the pilot bushing or bearing.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed pilot bushing or bearing following outlined procedures.	_____	_____
3. Inspected pilot bushing or bearing for damage.	_____	_____
4. Cleaned crankshaft bore prior to pilot bushing/bearing installation.	_____	_____
5. Prelubricated pilot bushing or bearing correctly, if needed.	_____	_____
6. Replaced and lubricated pilot bushing or bearing following outlined procedures.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 8

Inspect, remove, repair, service, and replace flywheel and ring gear.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected flywheel and ring gear correctly.	_____	_____
3. Remove the flywheel and ring gear following outlined procedures.	_____	_____
4. Inspected the crankshaft before replacing the flywheel and ring gear.	_____	_____
5. Replaced the flywheel and ring gear following outlined procedures.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 9 **Measure crankshaft end play and flywheel runout.**

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Cleaned and positioned crankshaft flange correctly prior to crankshaft end play measurement.	_____	_____
3. Measured crankshaft end play according to outlined procedures.	_____	_____
4. Measured flywheel runout according to outlined procedures.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 10

Inspect the engine block, clutch housing, and transmission housing mating surfaces.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Checked engine block, clutch housing, and transmission housing for lubrication leaks.	_____	_____
3. Cleaned component surfaces correctly.	_____	_____
4. Inspected component surfaces and corrected small imperfections.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 11

Measure clutch housing face runout and clutch housing bore runout.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Assembled and installed the clutch housing alignment tools correctly.	____	____
3. Measured clutch housing face runout according to outlined procedures.	____	____
4. Measured clutch housing bore runout according to outlined procedures.	____	____
5. If either runout was not within specifications, repositioned clutch alignment tool and/or clutch housing and checked the accuracy of the measurement.	____	____
6. Observed safety rules and precautions.	____	____
7. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 12

Replace the clutch housing and transmission.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the vehicle's service manual as a reference throughout the job sheet procedure.	_____	_____
3. Checked to make sure prerequisite tasks were complete before beginning job sheet.	_____	_____
4. Replaced the clutch housing correctly.	_____	_____
5. Replaced the transmission on the clutch housing following outlined procedures.	_____	_____
6. Replaced the transmission crossmember correctly.	_____	_____
7. Reconnected the clutch and transmission shift linkages and other cables, wires, and connections correctly.	_____	_____
8. Filled the transmission lubricant according to outlined procedures.	_____	_____
9. Completed the procedure as outlined.	_____	_____
10. Observed safety rules and precautions.	_____	_____
11. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE CLUTCHES

NAME ______________________ SCORE ______

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive clutch by selecting the correct definition from four choices. Select the best answer for each term.

______1. **adjusting the clutch**

A. The process of adjusting the distance the clutch pedal must move before the clutch is engaged
B. The process of tightening the clutch linkage
C. The process of adjusting how tightly the clutch disc is held between the flywheel and the pressure plate when the clutch is engaged
D. The process of adjusting the distance the clutch pedal moves before the release bearing contacts the pressure plate assembly

______2. **alignment**

A. The position of connecting parts so they function in a straight line
B. The proper position of parts or components in relation to each other
C. A condition in which a part or parts are stuck or otherwise kept from moving in their normal way
D. A method of fitting parts together without fasteners

______3. **bell-mouthing** (in a clutch)

A. A pattern of wear in which the splines on the hub of a clutch disc are more worn *away* from the axis than they are *near* the axis
B. A pattern of wear in which the splines on the hub of a clutch disc are more worn *near* the axis than they are *away* from the axis
C. Excessive runout in the bell housing
D. Improper bore alignment of the bell housing

______4. **binding**

A. A method of fitting parts together with metal supporting straps
B. A type of clutch problem in which the clutch disc does not come to a complete stop within 5 seconds after being disengaged
C. A condition in which a part or parts are stuck or otherwise kept from moving in their normal way
D. When the clutch pedal stays on the floor after being depressed

______5. **bleeding the clutch**

A. Removing air from the hydraulic clutch system
B. Removing hydraulic fluid from the hydraulic clutch system
C. Removing water from the hydraulic clutch system
D. Stripping the cable in a hydraulic clutch system

______6. **bushing**

A. A shaft or pin on which something turns
B. A small antifriction bearing
C. Oil impregnated metal
D. A cylindrical metal lining designed to promote the smooth movement of an adjoining rotating part

______7. **centrifugal force**

A. A property of matter in which an object at rest tends to remain at rest, and an object in motion tends to remain in motion, unless either object is acted upon by an outside force
B. A force that pushes an object or parts of an object outward from the center of rotation
C. Gravity
D. In a clutch assembly, the friction which controls the clutch's rotational force when the clutch is engaged

______8. **clutch chatter**

A. A type of clutch problem in which a shuddering vibration is felt throughout the vehicle when the clutch disc is first contacted by the pressure plate
B. A type of clutch problem in which the clutch disc does not come to a complete stop within 5 seconds after being disengaged
C. A type of clutch problem in which the clutch disc is not clamped firmly between the pressure plate and the flywheel when the clutch is engaged
D. A type of clutch noise caused by worn splines on the clutch disc and the transmission input shaft

______9. **clutch drag**

A. Binding in the clutch pedal
B. A type of clutch problem in which the clutch disc does not come to a complete stop within the amount of time specified by the vehicle's manufacturer after the clutch is disengaged
C. A type of clutch problem in which a shuddering vibration is felt throughout the vehicle when the clutch disc is first contacted by the pressure plate
D. A type of clutch problem in which the clutch disc is not clamped firmly between the pressure plate and the flywheel when the clutch is engaged

_____10. **clutch pedal free travel**

A. The distance a clutch pedal moves before engaging the clutch
B. The distance a clutch pedal moves from its return position until it is fully depressed
C. A condition in which the clutch pedal moves without binding or sticking
D. The distance the clutch pedal moves before the release bearing contacts the pressure plate assembly

_____11. **clutch slippage**

A. A type of clutch problem in which a shuddering vibration is felt throughout the vehicle when the clutch disc is first contacted by the pressure plate
B. A type of clutch problem in which the clutch linkage fails to disengage the clutch
C. A type of clutch problem in which the clutch disc is not clamped firmly between the pressure plate and the flywheel when the clutch is engaged
D. A type of clutch problem in which the clutch disc does not come to a complete stop within the amount of time specified by the vehicle's manufacturer after the clutch is disengaged

_____12. **compress**

A. To press or squeeze together
B. To reduce the activity of something
C. A thin flexible disc
D. To draw back

_____13. **dampen**

A. To press or squeeze together
B. To reduce the activity of something
C. To stop the rotation of something
D. The twisting of one part around another

_____14. **diaphragm**

A. A wide rubber gasket
B. A shaft or pin on which something turns
C. A thin flexible disc
D. The rubber shaft in a hydraulic master cylinder

_____15. **disengaged** (in a clutch)

A. When the clutch *is not* transmitting the engine's turning power from the engine to the transmission
B. When the clutch *is* transmitting the engine's turning power from the engine to the transmission.
C. When the clutch linkage *is not* turning the transmission input shaft
D. When the clutch pedal *is not* pressed down

_____16. **engaged** (in a clutch)

A. When the clutch *is not* transmitting the engine's turning power from the engine to the transmission
B. When the clutch *is* transmitting the engine's turning power from the engine to the transmission
C. When the clutch linkage is turning the transmission input shaft
D. When the clutch pedal is pressed down

_____17. **hydraulic**

A. Pressed or squeezed together
B. Operated without electrical power
C. Operated by fluid under pressure
D. Operated by power cables

_____18. **inertia**

A. A property of matter in which an object at rest tends to remain at rest, and an object in motion tends to remain in motion, unless either object is acted upon by an outside force
B. A method of fitting two parts tightly together without fasteners. The outer part is heated and the inner part is cooled before joining
C. A force that pushes an object or parts of an object outward from the center of rotation
D. In a clutch assembly, the friction which controls the clutch's rotational force when the clutch is engaged

_____19. **integral**

A. Not essential
B. A whole number
C. Divided in sections
D. Formed as a unit with another part

_____20. **linkage**

A. A shaft or pin on which something turns
B. Formed as a unit with another part
C. The proper position of parts or components in relation to each other
D. Parts that connect one assembly or part to another

_____21. **pivot**

A. A thin flexible disc
B. A shaft or pin on which something turns
C. Opposing
D. A lever in the pressure plate assembly

_____22. **porous**

A. Fluid
B. A quality of spring steel
C. Flexible
D. Containing tiny openings into which liquid may pass

_____23. **resistant**

A. To reduce the activity of something
B. The twisting of one part around another
C. Opposing
D. Changing

_____24. **retract**

A. To draw back
B. To oppose
C. To twist one part around another
D. To clamp

_____25. **riding the clutch**

A. When the driver pushes the clutch pedal too far down when disengaging the clutch
B. When the release bearing sits on the pressure plate assembly because of an improperly adjusted clutch
C. When the driver allows his foot to remain on the clutch pedal when not disengaging the clutch
D. When the driver engages the clutch too quickly when starting the vehicle

_____26. **shrink fit**

A. Two parts that fit together so tightly that special (often hydraulic) tools are required to force them together or apart
B. A method of fitting two parts tightly together without fasteners. The outer part is heated and the inner part is cooled before joining
C. A method of fitting two parts tightly together without fasteners. The outer part is cooled and the inner part is heated before joining
D. When two parts are fastened together by heated rivets

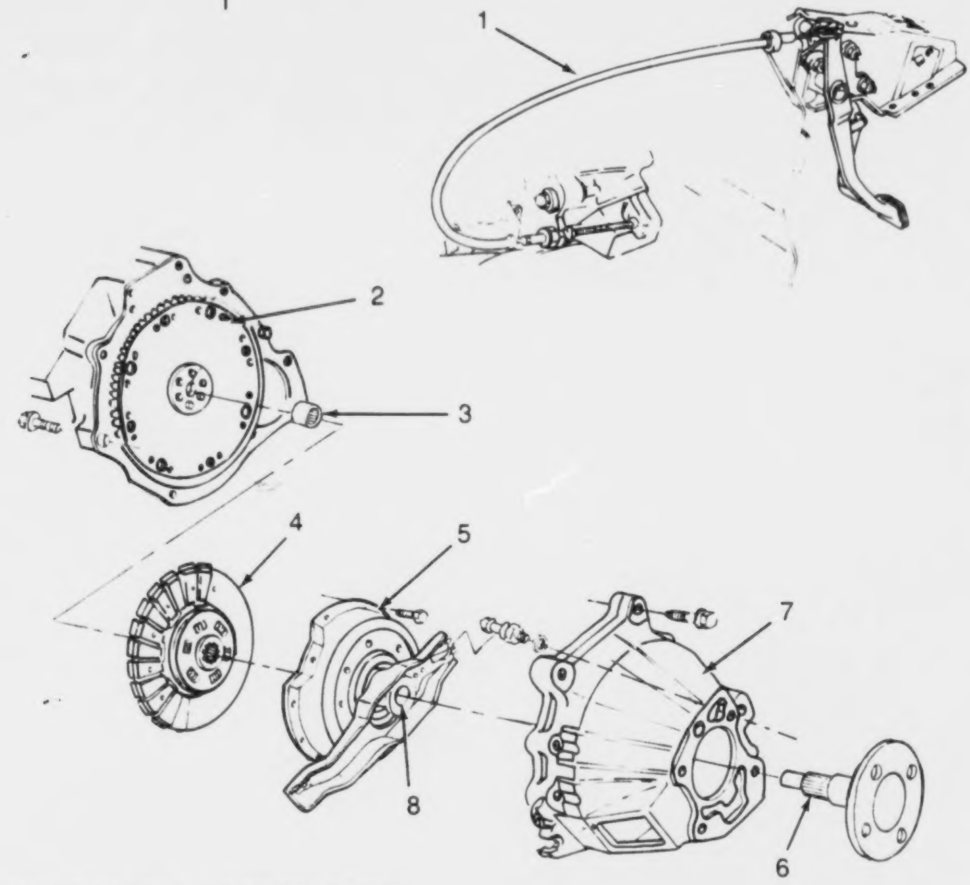
_____27. **spin-down time** (in a clutch)

A. The method of measuring clutch slippage
B. The amount of time it takes for the flywheel to stop spinning when the clutch is disengaged
C. The amount of time it takes for the clutch disc to stop spinning when the clutch is disengaged
D. The amount of time it takes the engine torque to get to the drive wheels from the crankshaft

_____28. **torsional**

A. The amount of pressure (in. lbs. per foot) that can be placed on a spring
B. The twisting of one part around another
C. The speed at which something turns
D. Having tiny openings into which liquid may pass

OBJECTIVE 2 | **Label the major components of the clutch system on an illustration.**



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Write the name of the component indicated in the blank.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________

OBJECTIVE 3

Match the names of clutch components to phrases describing the components or giving their functions. Use the following list for both parts of the this question.

A. Clutch disc
B. Clutch housing
C. Clutch linkage
D. Flywheel
E. Pilot bushing/bearing
F. Pressure plate assembly
G. Release bearing assembly
H. Transmission input shaft

A. **Descriptions:**

Write the letter of the clutch component being described.

______1. Made of high quality steel, this component is the shaft of the transmission's main drive gear

______2. An aluminum or cast iron container bolted to the engine block on one side and either bolted to, or an integral part of, the transmission on the other

______3. A metal assembly which is bolted to the flywheel, surrounding the clutch disc

______4. A series of mechanical and/or hydraulic components which begins with the clutch pedal and ends with the release fork

______5. A sleeve made of porous bronze impregnated with oil which is press fit into the socket of the engine crankshaft. A ball bearing or a needle bearing sometimes replaces this component

______6. A sealed bearing press fit to a collar, this component surrounds the transmission input shaft's bearing retainer in a position between the release fork and the pressure plate assembly

______7. A disc-shaped assembly made of high quality steel faced with friction material, which is splined to the transmission input shaft in a position between the flywheel and the pressure plate in the pressure plate assembly

______8. A large, heavy, machined disc made of iron or aluminum faced with iron which is bolted to the engine crankshaft

A. Clutch disc
B. Clutch housing
C. Clutch linkage
D. Flywheel
E. Pilot bushing/bearing
F. Pressure plate assembly
G. Release bearing assembly
H. Transmission input shaft

B. **Functions:**

Write the letter of the correct clutch component by the component function. Each component may be used more than once.

______1. Transfers torque from the rotating flywheel and pressure plate to the transmission input shaft

______2. Responds to pressure from the release bearing to release the clutch disc and disengage the clutch

______3. Protects the starter and clutch components (except the clutch linkage) from dirt, water, and heat build-up

______4. Smoothes out the vibrations caused by the engine firing pulses

______5. Transfers engine torque from the clutch disc to the transmission

______6. Supplies the clutch with its driving force

______7. Aligns the engine with the transmission

______8. Clamps the clutch disc tightly against the flywheel when the clutch is engaged

______9. Transfers the action of the driver's foot on the clutch pedal into pressure on the release bearing assembly

_____10. Provides a mounting for the flywheel ring gear (which, when turned by the vehicle's staring system, starts the engine)

_____11. Aligns the transmission input shaft to the crankshaft

_____12. Allows the socket of the crankshaft to rotate freely around the transmission input shaft when the clutch is disengaged

_____13. Cushions the initial jolt of power as engine torque is transferred to the transmission gears

_____14. Supports the transmission, starter, and parts of the clutch linkage

_____15. Transfers pressure from the clutch linkage to the pressure plate assembly to disengage the clutch

_____16. Provides a place to mount the pressure plate assembly

_____17. Supports the front part of the transmission input shaft

_____18. Rotates with the pressure plate while the clutch is disengaged

_____19. Provides rotating inertia which carries the engine parts over the non-power parts of their strokes

OBJECTIVE 4

Identify the operating condition of the major clutch components in both the engaged and the disengaged positions. Put an **E** before the condition which exists when the clutch is *engaged* and a **D** before the condition which exists when the clutch is *disengaged*.

______1. The clutch disc is rotating, clamped tightly between the rotating pressure plate and the flywheel.

______2. The driver's foot is not on the clutch pedal.

______3. Rotating with the engine, the flywheel is turning the pressure plate assembly, but not the clutch disc.

______4. The pressure plate assembly is rotating and the pressure plate springs have forced the pressure plate against the clutch disc, clamping it firmly against the rotating flywheel.

______5. The clutch disc is not turning the transmission input shaft, but the leftover movement (inertia) in the transmission may be turning it.

______6. The release fork has pushed the release bearing against the pressure plate spring/levers. The release bearing rotates with the pressure plate assembly when it presses down the spring.

______7. The rotating clutch disc is turning the transmission input shaft.

______8. The clutch disc is not in contact with the rotating pressure plate and flywheel. If the clutch disc is still rotating, it does so because the transmission input shaft has not yet slowed down.

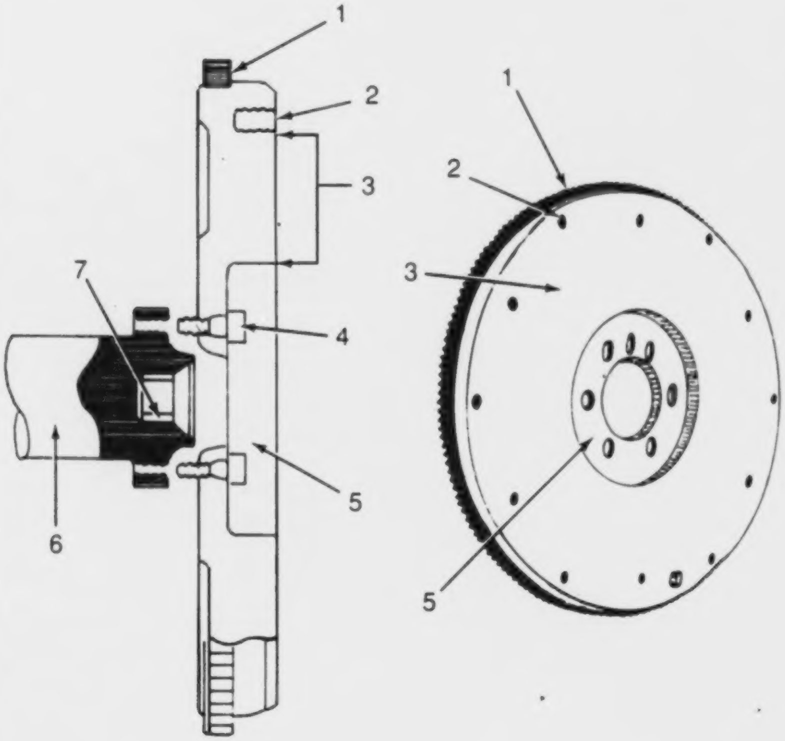
______9. The driver's foot is pressing down on the clutch pedal.

_____10. The pressure plate assembly is rotating, but the pressure of the release bearing on the pressure plate spring/levers has forced the pressure plate to move away from the clutch disc, releasing it from the flywheel.

_____11. Rotating with the engine crankshaft, the flywheel is turning the pressure plate assembly and the clutch disc.

_____12. The release bearing is not rotating or touching the pressure plate assembly.

OBJECTIVE 5 **Match the names of the parts of a flywheel to an illustration.**



Put the letter of the part indicated in the blank.

______1. A. Area of clutch disc contact

______2. B. Crankshaft

______3. C. Flywheel mounting bolt

______4. D. Hole for pressure plate mounting bolt

______5. E. Pilot bushing/bearing

______6. F. Recess for clutch disc hub

______7. G. Ring gear

OBJECTIVE 6 **Label three types of pressure plate assemblies and match the names of their parts to illustrations.** Write the *type* of pressure plate assembly in the large blank and the letter of the correct part in the blank indicated.

A. Type of pressure plate assembly: ______________________

A. Diaphragm spring
B. Drive strap
C. Drive strap rivet
D. Gasket
E. Pressure plate
F. Pressure plate cover
G. Spring pivot rivet

______1.

______2.

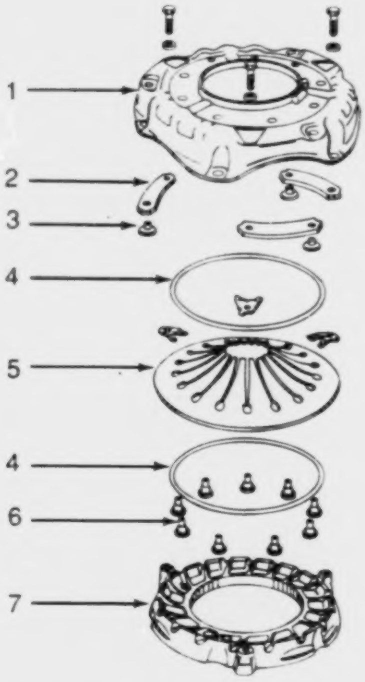
______3.

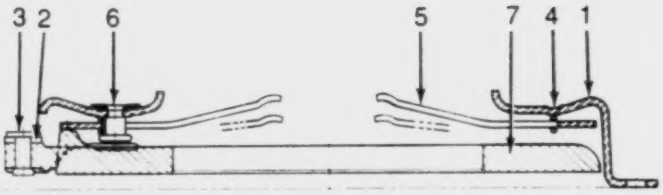
______4.

______5.

______6.

______7.





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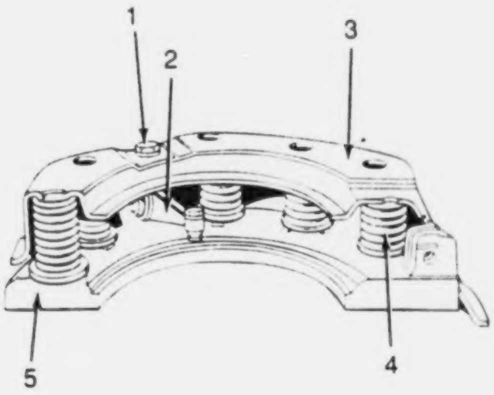

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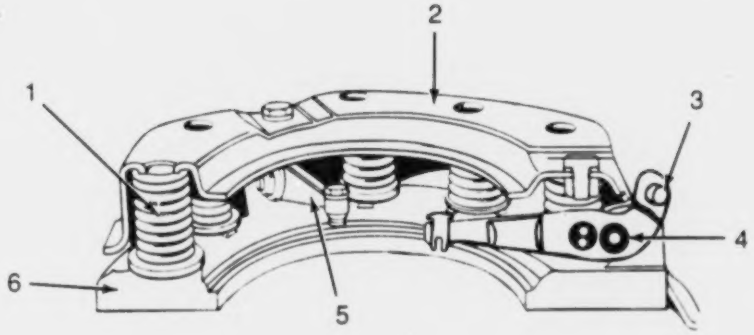
B. Type of pressure plate assembly: ____________________

______1.	A.	Coil spring
______2.	B.	Lever adjusting nut
______3.	C.	Pressure plate
______4.	D.	Pressure plate cover
______5.	E.	Release lever



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C. Type of pressure plate assembly: ______________________

______1. A. Coil spring

______2. B. Pivot

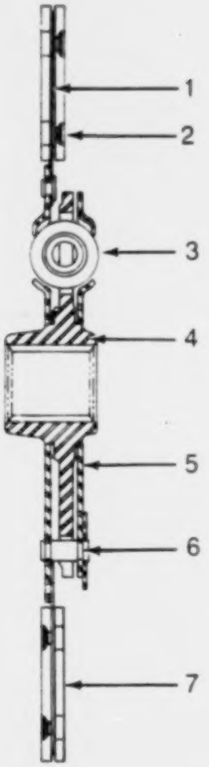
______3. C. Pressure plate

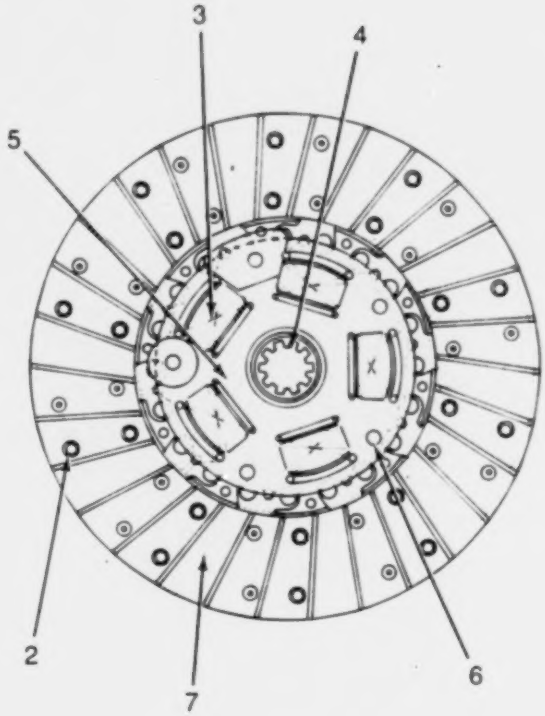
______4. D. Pressure plate cover

______5. E. Release lever

______6. F. Weight

OBJECTIVE 7 | **Match the names of the parts of a clutch disc to illustrations.**





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Put the letter of the part indicated in the blank.

______1. A. Cushion spring

______2. B. Facings

______3. C. Hub and hub flange

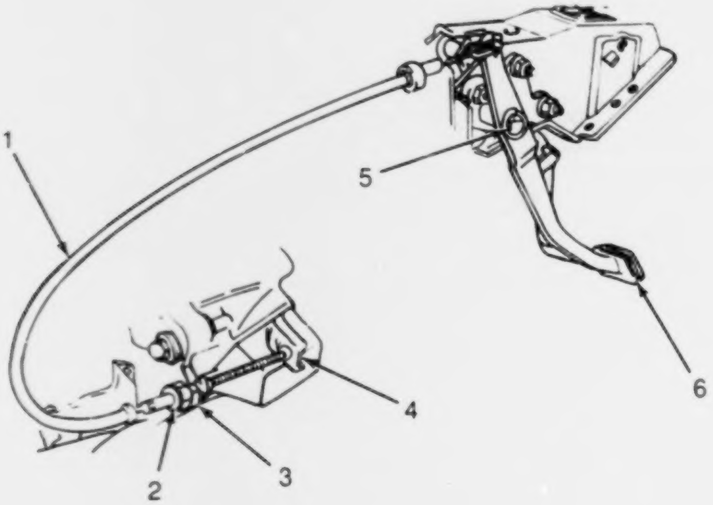
______4. D. Rivets

______5. E. Side plates

______6. F. Stop pins

______7. G. Torsional dampener springs

OBJECTIVE 8 **Label three types of clutch linkages and match the names of their parts to illustrations.** Write the *type* of clutch linkage in the large blank and the letter of the correct part in the blank indicated. Some parts may be used more than once.



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A. Type of clutch linkage: ____________________

______1. A. Adjusting nut

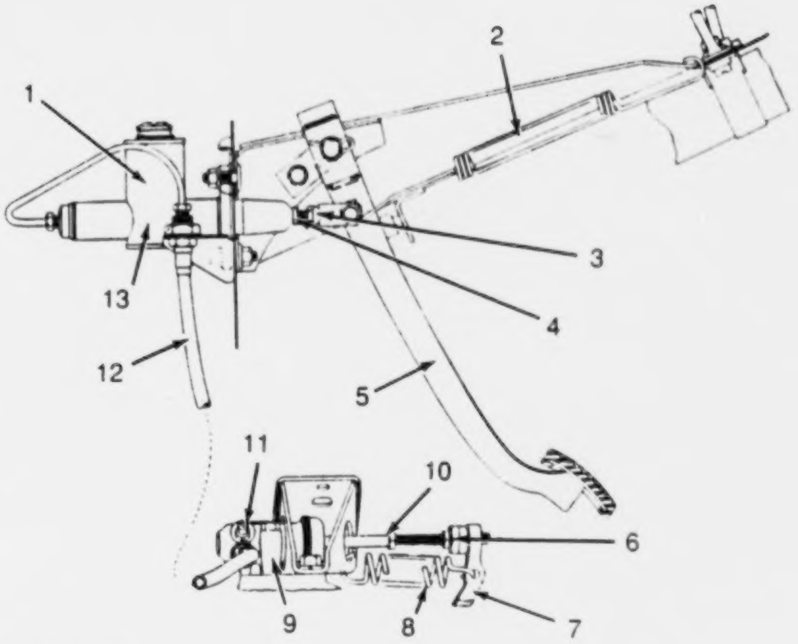
______2. B. Cable lock nut

______3. C. Clutch cable

______4. D. Clutch pedal

______5. E. Pivot

______6. F. Release fork



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B. Type of clutch linkage: ______________________________

______1.

______2.

______3.

______4.

______5.

______6.

______7.

______8.

______9.

______10.

______11.

______12.

______13.

A. Bleeder screw

B. Clutch pedal

C. Hydraulic line

D. Master cylinder

E. Master cylinder adjusting nut

F. Master cylinder fluid reservoir

G. Push rod

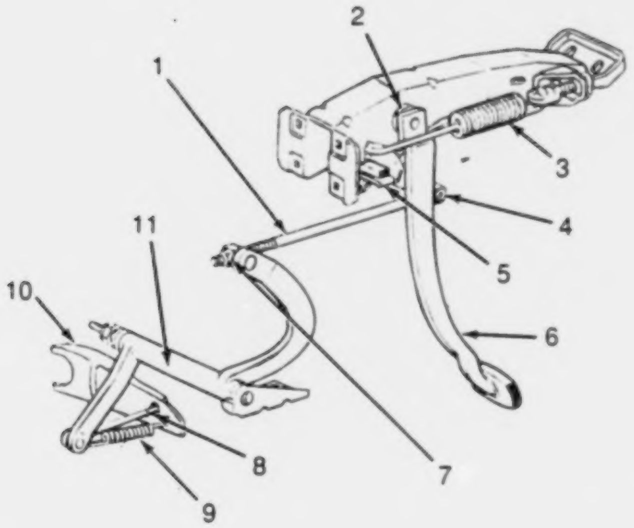
H. Push rod locknut

I. Release fork

J. Return spring

K. Slave cylinder

L. Slave cylinder adjusting nut



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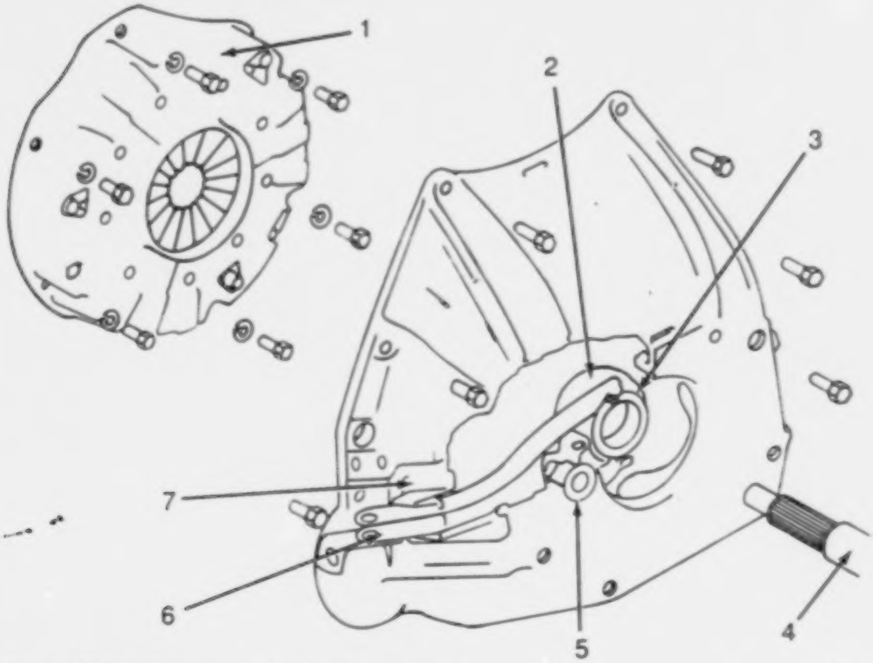
C. Type of clutch linkage: ______________________________

______1.	A. Assist spring
______2.	B. Bellcrank
______3.	C. Bracket
______4.	D. Clutch pedal
______5.	E. Clutch pedal push rod
______6.	F. Front adjusting nut
______7.	G. Pivot
______8.	H. Rebound bumper
______9.	I. Release fork
______10.	J. Release rod
______11.	K. Return spring

OBJECTIVE 9 | **Label the parts involved in the clutch release mechanism on an illustration.**



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Write the name of the indicated part in the blank.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

WRITTEN TEST ANSWERS

SERVICE CLUTCHES

III

OBJECTIVE 1

1. D
2. B
3. A
4. C
5. A
6. D
7. B
8. A
9. B
10. D
11. C
12. A
13. B
14. C
15. A
16. B
17. C
18. A
19. D
20. D
21. B
22. D
23. C
24. A
25. C
26. B
27. C
28. B

OBJECTIVE 2

1. Clutch linkage
2. Flywheel
3. Pilot bushing/bearing
4. Clutch disc
5. Pressure plate assembly
6. Transmission input shaft
7. Clutch housing
8. Release bearing assembly

OBJECTIVE 3

A. **Descriptions:**

1. H
2. B
3. F
4. C
5. E
6. G
7. A
8. D

B. **Functions:**

1. A
2. F
3. B
4. D
5. H
6. D
7. B
8. F
9. C
10. D
11. E
12. E
13. A
14. B
15. G
16. D
17. E
18. D
19. D

OBJECTIVE 4

1. E
2. E
3. D
4. E
5. D
6. D
7. E
8. D
9. D
10. D
11. E
12. E

OBJECTIVE 5

1. G
2. D
3. A
4. C
5. F
6. B
7. E

OBJECTIVE 6

A. Diaphragm spring type pressure plate assembly

  1. F
  2. B
  3. C
  4. D
  5. A
  6. G
  7. E

B. Lever type pressure plate assembly

  1. B
  2. E
  3. D
  4. A
  5. C

C. Semi-Centrifugal type pressure plate assembly

  1. A
  2. D
  3. F
  4. B
  5. E
  6. C

OBJECTIVE 7

1. A
2. D
3. G
4. C
5. E
6. F
7. B

OBJECTIVE 8

A. Cable clutch linkage

1. C
2. A
3. B
4. F
5. E
6. D

B. Hydraulic clutch linkage

1. F
2. J
3. E
4. H
5. B
6. L
7. I
8. J
9. K
10. G
11. A
12. C
13. D

C. Rod and lever clutch linkage

1. E
2. G
3. A
4. H
5. C
6. D
7. F
8. J
9. K
10. I
11. B

OBJECTIVE 9

1. Pressure plate assembly
2. Release bearing
3. Release bearing collar
4. Transmission input shaft
5. Pivot
6. Release fork
7. Boot

OBJECTIVE SHEET

SERVICE MANUAL TRANSMISSIONS

IV

INTRODUCTION

The purpose of a transmission is to multiply and adjust the engine's torque to driving requirements. In a *manual* transmission, the driver makes these adjustments himself by shifting from one gear ratio to another as required. In an *automatic* transmission, the adjustments are made automatically and no action by the driver is necessary. A manual transmission has many different parts and looks very complicated, but actually it is not hard to understand. The difficulty in servicing transmissions occurs not because the transmission is complicated, but because there are so many different types.

PREREQUISITE

Before studying this unit, the student must have successfully completed Unit 3, *Service Clutches.*

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose manual transmission problems and service and repair the transmission. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Choose the correct definitions for terms associated with the automotive manual transmission by selecting the correct definition from four choices.
2. Identify common driving situations which require greater torque and those which require less torque.
3. Label the basic parts of a transmission on an illustration.
4. Match the names of the basic parts of a transmission to a description of their functions.

5. Match the names of the parts of a transmission housing to an illustration.
6. Label the parts of an input shaft assembly on an illustration.
7. Match the names of the parts of a countershaft assembly to an illustration.
8. Match the names of the parts of an output shaft to an illustration.
9. Label the parts of a speed gear on an illustration.
10. Label two types of synchronizer assemblies and their parts on illustrations.
11. Label the parts of a reverse idler gear assembly on an illustration.
12. Label the two types of transmission shift linkages and match the names of their basic parts to illustrations.
13. Trace the flow of power through each gear setting on illustrations of a five-speed transmission.
14. Diagnose manual transmission noise and performance problems. (Assignment Sheet 1)
15. Demonstrate the ability to:
    - A. Inspect, replace, and adjust the external shift linkage parts located outside the transmission housing. (Job Sheet 1)
    - B. Inspect and replace transmission mounts. (Job Sheet 2)
    - C. Disassemble a transmission. (Job Sheet 3)
    - D. Remove, inspect, and replace external shift assembly components located inside the transmission housing. (Job Sheet 4)
    - E. Remove, inspect, and replace internal shift assembly components. (Job Sheet 5)
    - F. Remove, inspect, and replace input shaft assembly components. (Job Sheet 6)
    - G. Remove, inspect and replace output shaft assembly components. (Job Sheet 7)

H. Remove, inspect, and replace synchronizer assembly components. (Job Sheet 8)

I. Remove, inspect, and replace countershaft assembly components. (Job Sheet 9)

J. Remove, inspect, and replace reverse idler gear assembly components. (Job Sheet 10)

K. Check and adjust end play in transmission shafts. (Job Sheet 11)

L. Clean and inspect the transmission housing and transmission housing components. (Job Sheet 12)

M. Assemble the transmission and complete transmission service. (Job Sheet 13)

PREPARATION

Review unit and plan presentation

- Study the specific objectives to determine the order in which you will present the objectives. Decide whether or not you wish to add additional objectives.
- Review teaching suggestions given in the Delivery section and plan classroom activities.
- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.
- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

Obtain supplemental materials

- Order films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrates job sheet skills. Videotape your own procedures if unable to obtain suitable media.
- Copies of current articles on subjects covered in this unit may be obtained by writing to the *Automotive Information Council's* Reference Center. They will also conduct a computer search for such articles. See the note in the section on Media for more information about this free service.
- Obtain competency profiles for this unit.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364, 1-800-522-5810, ext. 589 in-state; 1-800-654-4502 out-of-state.

- Note equipment and material needs for completing job sheets.

Prepare classroom and shop

- Display safety signs, posters, and charts that show manual transmission components and service, etc.
- Have magazine articles, specification guides, service manuals, mock-ups, and other references about manual transmissions available for student use.
- Check tools and equipment against job sheet requirements.

Administer Pretest

- Administer pretest.
- Use the pretest results to assess student competencies, considering the results as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the Introduction to the Unit in the Objective Sheet.
- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an Automotive Drivetrain and Axles Specialist.
- Raise a front-engine, rear-wheel drive vehicle on a hoist and show the students the systems and components covered by this unit. Use this opportunity to show them the method that will be used in your shop for exposing a vehicle's transmission for service.
- Discuss with the students the fact that the material in this unit applies to vehicles which have a front-engine and a rear-wheel drive. Point out that many modern automobiles now have front-wheel drive, but that trucks and larger automobiles still have rear-wheel drive configuration.
- Explain that basic information learned in this unit will also be applied later in units which apply to front-wheel drive and four-wheel drive vehicles. For example, the functions of gears and other transmission parts.

- Show the students that the Job Sheets in the unit are normally listed in the order they must be performed. Some tasks must be performed before others can be performed successfully. **This order is important** in the classroom and on the job. However, because procedures on different vehicles vary, the vehicle's service manual should always be consulted to assist in identifying the proper diagnosis, service, or repair sequence. Assist the students to identify the logic in this order as you work through the unit.

- Look at one of the later Job Sheets. Discuss the fact that the preparation and procedures that need to be completed before beginning the Job Sheet are described before the procedures are listed. The Job Sheet number in parenthesis refers to the Job Sheet which will instruct them how to perform that preliminary preparation or procedure.

Objective 1 Choose the correct definitions for terms associated with the automotive manual transmission by selecting the correct definition from four choices.

- Show examples or demonstrate terms where applicable.

Objective 2 Identify common driving situations which require greater torque and those which require less torque.

- Explain the difference between turning power (torque) and turning speed.

- Discuss the material in the box, "How the Transmission Increases Engine Torque."

- Use one gear as a sample driving gear and select gears of various sizes to represent the driven gear. Verbally quiz the students regarding the increase or decrease of torque as you change the size of the driven gear.

- Review the chart, "Typical Gear Ratios," and show the students the various size transmission speed gears as they appear installed in the transmission.

- Discuss the purpose and concept of *overdrive*, including the fact that fourth gear on a 4-speed transmission may or may not be an overdrive gear.

- Discuss the circumstances under which the use of an overdrive gear will result in fuel economy.

- Show the students an example of a separate overdrive unit.

Objective 3 Label the basic parts of a transmission on an illustration.

- Show the filmstrip, *The Auto Standard Transmission*, parts 1 and 2, "Transmission Principles," and "Basic Parts."
- Point out the basic parts of a transmission on an actual transmission and show how they fit together.
- Review Objective 3, Unit 2, on common gear types.

Objective 4 Match the names of the basic parts of a transmission to a description of their functions.

- Show the filmstrip, *The Auto Standard Transmission*, part 3, "Operations."
- Discuss the functions of the basic parts of a transmission.
- Rotate the input shaft on a transmission model to demonstrate how the parts of a transmission interact.

Objective 5 Match the names of the parts of a transmission housing to an illustration.

- Show students examples of as many different types of transmission housings as possible.
- Point out the design features of each type of transmission housing.
- Discuss how the transmission is removed from each type of transmission housing.
- Locate the transmission I.D. tag on each type of transmission housing.
- Have the students use vehicle service manuals to research the information available on transmission identification tags.
- Discuss transmission lubricants and the importance of using the correct lubricant for the vehicle.
- Point out the location of gaskets and seals in the housing that could be sources of lubricant leaks. Use Supplement 4, "Transmission Leak Diagnosis Chart."

Objective 6 Label the parts of an input shaft assembly on an illustration.

- Show the students examples of several different input shafts. Point out and discuss their various parts.
- Demonstrate how the input shaft interacts with the clutch assembly and with the other parts of the transmission such as the output shaft and the countershaft.
- Point out to the students how input shafts are installed in the transmission housing of several different types of transmissions.
- Discuss the boxed illustration, "Transmission Shafts," showing how the different shafts operate together.

Objective 7 Match the names of the parts of a countershaft assembly to an illustration.

- Show the students examples of several different countershaft assemblies and point out the differences in each.
- Show the students examples of cluster gears and discuss how cluster gears and countergears can be found on the countershaft in various combinations.
- Discuss the boxed material, "Constant Mesh Gears," and demonstrate the difference between a constant mesh gear and a sliding gear.
- Discuss lubrication in the transmission and the role the countershaft plays in lubrication. Point out other lubrication devices such as holes in shafts and gears and special grooves and channels in the transmission housing.
- Begin to help the students see how these basic parts of the transmission can be designed and put together in many different ways. Discuss this wide variety of designs as a significant challenge in working on a manual transmission.

Objective 8 Match the names of the parts of an output shaft to an illustration.

- Show the students examples of several different output shaft assemblies, particularly ones from transmissions with different numbers of gear ratios.
- Point out the different parts of an output shaft and discuss their functions.

- Discuss the boxed material, "Common Types of Transmissions."

- Give the students pictures of transmissions with different gear ratios and have them identify the type of transmission which is pictured.

- Have the students identify the various transmission gears on an actual transmission output shaft.

Objective 9 Label the parts of a speed gear on an illustration.

- Allow the students to handle a speed gear as you point out the basic parts.

- Demonstrate how speed gears can rotate in either direction on the output shaft and discuss why this is important when the transmission is in reverse.

Objective 10 Label two types of synchronizer assemblies and their parts on illustrations.

- Point out the parts of both types of synchronizers on actual components.

- Allow the students to handle both types of synchronizers and encourage them to quiz each other on their basic parts.

- Discuss the boxed material, "How a Synchronizer Works."

- Use an synchronizer and speed gear to demonstrate how a synchronizer contacts a speed gear to slow it down or speed it up.

Objective 11 Label the parts of a reverse idler gear assembly on an illustration.

- Show the students examples of different types of reverse idler gear assemblies.

- Point out that the reverse idler gear is contacted by *both* a gear on the countershaft assembly and one on the output shaft assembly.

- Use actual gears to demonstrate the boxed material, "How the Reverse Idler Assembly Changes the Direction of the Output Shaft."

Objective 12 Label the two types of transmission shift linkages and match the names of their basic parts to illustrations.

- Show the students several examples of the two different types of shift linkages, pointing out their basic parts.
- Use actual components to demonstrate how the shift linkages shift the transmission gears.
- Discuss and demonstrate the material in the three boxes, "How the Internal Shift Linkage Fits in the Transmission Housing," "Shift Interlock Mechanism," and "How a Driver Can 'Feel' Whether He Has Shifted Correctly."

Objective 13 Trace the flow of power through each gear setting on illustrations of a five-speed transmission.

- Discuss the material in the note with the class, pointing out the difference between a gear which is turning and a gear which is turning *under load*.
- Discuss the terms *high gear*, *low gear*, and *neutral* in relation to the flow of power through the transmission gears.
- Hand out copies of the illustrations of a transmission from Objective #13 on the Written Test and have the students practice tracing the flow of power through the gears.
- If you desire, you may want to cover the material in Supplement 5, "How to Figure Transmission Gear Ratios—The Torque Multiplication Factor," and Activity Sheet 1, "Figuring Transmission Torque Multiplication Ratios," at this point. *This is optional material and can be included if the instructor chooses.*

APPLICATION

Objective 14 Diagnose manual transmission noise and performance problems. (Assignment Sheet 1)

- Discuss the material in Supplement 1, "Transmission Troubleshooting Guide," with the students.
- Review the material in Supplements 2, 3, & 4, diagnostic charts for transmission performance, noise, and leaks. Point out that the possible causes for a condition which are listed first are more probable.
- Use the slides, *Noise, Vibration, and Harshness*, and the video, *NVH Vehicle Diagnosis*, to assist with identifying problem transmission noises.

- Show the filmstrip, *The Auto Standard Transmission*, parts 4 & 5, "Problems, Causes and Corrections—I & II."

- Have students complete Assignment Sheet 1.

Objective 15A Inspect, replace, and adjust the external shift linkage parts located outside the transmission housing. (Job Sheet 1)

- Show the students several different ways that linkage rods are connected to arms and levers.

- Demonstrate appropriate methods of disconnecting and reconnecting these rods.

- Display an example of an actual external linkage that is out of adjustment and/or has worn or damaged parts.

- Show examples of linkage rods which are made in a bent design. Discuss the importance of referring to the service manual to determine the *correct* shape of the rods in the transmission shift linkage.

- While working inside the passenger compartment, show the students how to cover the front seat to protect it while working inside the vehicle.

- Demonstrate how to use a service manual to carry out the activities in the job sheet.

- Explain that some parts of an external shift linkage are located inside the transmission housing and that the overhaul of these parts is covered in Job Sheet 4.

- Have the students complete Job Sheet 1.

Objective 15B Inspect and replace transmission mounts. (Job Sheet 2)

- Show the students several different types of transmission mounts.

- Demonstrate how to inspect and replace these examples.

- Display examples of worn or damaged transmission mounts.

- Have the students complete Job Sheet 2.

Objective 15C Disassemble a transmission. (Job Sheet 3)

- Show the filmstrip, *The Auto Standard Transmission*, part 6, "How to Overhaul a Transmission—The Disassembly."
- Stress that the order in which the vehicle's manufacturer suggests that the disassembly be made may not agree with the order in which the Job Sheets are presented in this unit. The student should follow the manufacturer's recommendations regarding order of disassembly.
- Discuss the Guidelines for disassembling a transmission with the students.
- Show examples of needle bearings, snap rings, and bolts and demonstrate how easy it is to get these small parts mixed up after the transmission is disassembled.
- Discuss with the students the fact that many overhaul procedures (such as this one) involving the transmission cannot follow a "standard" procedure set out in a job sheet. Because of the dozens of types of transmissions, there is no *one* "most common" procedure—the appropriate service manual must be used. Point out that this is good practice for them because this is the way these procedures must be done in a regular shop environment.
- Stress that learning to use a service manual correctly is a very important part of their training.
- Select a vehicle from your shop and show the students how to use the service manual to carry out the activities in this job sheet.
- Have the students complete Job Sheet 3.

Objective 15D Remove, inspect, and replace external shift assembly components located inside the transmission housing. (Job Sheet 4)

- Discuss the job sheet Guidelines with the students.
- Demonstrate Guideline activities where appropriate.
- Display examples of worn or damaged parts of an external shift assembly which are located inside the transmission housing.
- Select a vehicle from your shop and show the students how to use the service manual to carry out the activities in the job sheet.

- Have the students complete Job Sheet 4.

Objective 15E Remove, inspect, and replace internal shift assembly components. (Job Sheet 5)

- Discuss the job sheet Guidelines with the students.
- Show an example of a rail that is too loose in the housing bore.
- Demonstrate other Guideline activities where appropriate.
- Display examples of worn or damaged parts of an internal shift assembly.
- Show the students how to use the service manual to carry out the activities in the job sheet.
- Have the students complete Job Sheet 5.

Objective 15F Remove, inspect, and replace input shaft assembly components. (Job Sheet 6)

- Discuss the job sheet Guidelines with the students.
- Demonstrate how to use petroleum jelly to install needle or roller bearings in the bore of the input gear.
- Demonstrate other Guideline activities where appropriate.
- Display examples of worn or damaged parts of an input shaft assembly.
- Demonstrate how to use snap-ring pliers.
- Determine whether the students are familiar with the use of other equipment or tools that are used to perform this job sheet. Demonstrate the use of any unfamiliar equipment.
- Show the students how to use the service manual to carry out the activities in the job sheet.
- Have the students complete Job Sheet 6.

Objective 15G Remove, inspect and replace output shaft assembly components. (Job Sheet 7)

- Show the filmstrip, *Servicing the Standard Transmission*, parts 1 & 3, "Removing the Mainshaft Gear Assembly," and "Servicing the Mainshaft Gear Assembly."

- Show the students examples of different types of speedometer assemblies and demonstrate how they are removed, inspected, and replaced.
- Discuss the job sheet Guidelines with the students.
- Demonstrate Guideline activities where appropriate.
- Display examples of worn or damaged parts of an output shaft assembly.
- Determine whether the students are familiar with the use of the equipment and tools that are used to perform this job sheet. Demonstrate the use of any unfamiliar equipment.
- Show the students how to use the service manual to carry out the activities in the job sheet.
- Have the students complete Job Sheet 7.

Objective 15H Remove, inspect, and replace synchronizer assembly components. (Job Sheet 8)

- Discuss the job sheet Guidelines with the students.
- Demonstrate how to remove and replace a synchronizer assembly using an arbor press. If possible, also demonstrate on a synchronizer that must be heated in order to be removed.
- Demonstrate other Guideline activities where appropriate.
- Display examples of worn or damaged parts of both types of synchronizers.
- Show the students how to use the service manual to carry out the activities in the job sheet.
- Have the students complete Job Sheet 8.

Objective 15I Remove, inspect, and replace countershaft assembly components. (Job Sheet 9)

- Show the filmstrip, *Servicing the Standard Transmission*, part 2, "Servicing the Reverse Idler and Counter Gears."
- Discuss the job sheet Guidelines with the students.
- Demonstrate Guideline activities where appropriate.

- Display examples of worn or damaged parts of a countershaft assembly.

- Show the students how to use the service manual to carry out the activities in the job sheet.

- Have the students complete Job Sheet 9.

Objective 15J Remove, inspect, and replace reverse idler gear assembly components. (Job Sheet 10)

- Discuss the job sheet Guidelines with the students.

- Demonstrate Guideline activities where appropriate.

- Display examples of worn or damaged parts of a reverse idler gear assembly.

- Show the students how to use the service manual to carry out the activities in the job sheet.

- Have the students complete Job Sheet 10.

Objective 15K Check and adjust end play in transmission shafts. (Job Sheet 11)

- Demonstrate how to check transmission end play using both a dial indicator and a feeler gauge.

- Point out positions on the shafts where such end play is sometimes checked.

- Have the students use the service manuals available in the shop to determine the five points of information (See introductory material for the job sheet.) they will need in order to check shaft end play in the vehicle.

- Have the students complete Job Sheet 11.

Objective 15L Clean and inspect the transmission housing and transmission housing components. (Job Sheet 12)

- Discuss the job sheet Guidelines with the students.

- Demonstrate how to use liquid sealant to install a gasket on a transmission housing.

- Show the students how to repair stripped thread bores.

- Demonstrate other Guideline activities where appropriate.

- Display examples of worn or damaged transmission housings.
- Show the students how to use the service manual to carry out the activities in the job sheet.
- Have the students complete Job Sheet 11.

Objective 15M Assemble the transmission and complete transmission service. (Job Sheet 13)

- Show the filmstrip, *The Auto Standard Transmission*, part 7, "How to Overhaul a Transmission—The Assembly."
- Show the filmstrip, *Servicing the Standard Transmission*, part 4, "Completing the Assembly."
- Discuss the job sheet Guidelines with the students.
- Demonstrate how to test the transmission by shifting through the gears while the transmission is still off the vehicle.
- Demonstrate other Guideline activities where appropriate.
- Show the students how to use the service manual to carry out the activities in the job sheet.
- Have the students complete Job Sheet 12.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.
- Evaluate class members on assignment sheet activities if not previously done. Provide them with copies of Supplement 1, "Transmission Troubleshooting Guide," Supplement 2, "Transmission Performance Diagnosis Chart," Supplement 3, "Transmission Noise Diagnosis Chart," and Supplement 4, "Transmission Leak Diagnosis Chart."
- Give the practical tests. Evaluate tests on forms provided.
- Reteach and retest as required.
- Complete the appropriate section of the competency profiles.
- Review individual and group performance in order to evaluate teaching methods.

- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- Abbott, Sheldon L. *Automotive Power Trains*, 2nd ed. Encino, California: Glencoe Publishing Co., 1988.
- *Car 1987 Shop Manual—Powertrain, Lubrication, Maintenance.* Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.
- *Chilton's Auto Repair Manual 1983-1990.* Radnor, Pennsylvania: Chilton Book Co., 1989.
- *Chilton's Import Car Manual 1983-1990.* Radnor, Pennsylvania: Chilton Book Co., 1989.
- *Clutches and Manual Transmissions.* Detroit, Michigan: General Motors Corp., 1982.
- Crouse, William H., and Donald L. Anglin. *The Auto Book*, 3rd ed. New York: Gregg Division, McGraw-Hill, 1984.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill, 1985.
- Crouse, William H., and Donald L. Anglin. *Automotive Transmissions and Power Trains*, 5th ed. New York: Gregg Division, McGraw-Hill, 1976.
- Crouse, William H., and Donald L. Anglin. *Manual Transmissions and Power Trains*, 6th ed. New York: Gregg Division, McGraw-Hill, 1983.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.
- *Diagnosis of Manual Transmission.* Detroit, Michigan: Ford Service Publications, 1976.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- Erjavec, Jack. *Manual Transmissions and Transaxles.* New York City: Harcourt Brace Jovanovich, Technology Publications, 1990.

- *Five-Speed Manual Overdrive Transmission.* Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1980.
- Hughes, James G. *Guide to Automobile Certification Examination*, revised ed. Reston, Virginia: Reston Publishing Co., Inc., a Prentice-Hall Company, 1983.
- *Introduction to Automotive Service.* Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1989.
- Kovacik, Robert T., and Clifford Creager. *Manual Transmissions and Drivetrains.* Cincinnati, Ohio: South-Western Publishing Co., 1984.
- Mitchell Information Services, Inc. *Mitchell Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- *Mitchell 1984 Edition Transmission Service and Repair.* San Diego, California: Mitchell Manuals, Inc., 1984.
- *Muncie HM-290 Series Manual Transmissions.* Detroit, Michigan: General Motors Corp., 1987.
- *NP 2500 Transmission.* Center Line, Michigan: Chrysler Motors, Training Program Development, 1981.
- *Official ASE Preparation Guide to ASE Automobile Tests, The.* Reston, Virginia: National Institute for Automotive Service Excellence, 1989.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1982.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.
- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1983.
- *TOD and SROD Four-Speed Manual Transmissions.* Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1983.

- Webster, Jay. *Auto Mechanics*, 2nd ed. Encino, California: Glencoe Publishing Co., Inc., 1986.

- Webster, Jay. *Automotive Power Train Systems*. Homewood, Illinois: American Technical Publishers, Inc., 1982.

- White, John H. *Manual Transmissions and Drivetrains*. Albany, New York: Delmar Publishers Inc., 1987.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Auto Standard Transmission, The*. 7 filmstrips, 11-14 minutes each. Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565. Transmission Principles; Basic Parts; Operations; Problems, Causes and Corrections—Part 1; Problems, Causes, and Corrections—Part 2; How to Overhaul a Transmission—The Disassembly; How to Overhaul a Transmission—The Assembly.

- *Automotive Information Council—Reference Center*. 13505 Dulles Technology Drive, Herndon, Virginia 22071-3415, phone (703) 904-0700. The AIC Reference Center has a reference base of over 10,000 volumes, maintaining subscriptions to over 100 trade and consumer publications relating to the automotive industry. Their computer indexing system can provide educators with up-to-date print-outs of books, articles from periodicals, statistical abstracts, press releases, catalogues, and other reference materials on 90 automotive subject classifications. AIC's services are free of charge. Copies of current articles from periodicals are also available free if requested in nominal quantities.

- *Noise, Vibration and Harshness*. 50 color slides, 58 p. Instructor Guide, and 46 p. Student Text. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. The object of this text is to improve mechanical skills, to increase the accuracy of diagnosis, and to provide time-saving procedures for the identification and elimination of problems relating to vehicle noise, vibration, and harshness.

- *NVH Vehicle Diagnosis*. 26 minutes, color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Defines noise, vibration, and harshness concerns; provides diagnostic theory and repair procedures in step-by-step format.

- *Servicing the Standard Transmission*. 4 filmstrips. Vocational Media Associates, P.O. Box 1050, Mount Kisco, New York 10549-9989, phone 1-800-431-1242. Removing the Mainshaft Gear Assembly; Servicing the Reverse Idler and Counter Gears; Servicing the Mainshaft Gear Assembly; Completing the Assembly.

SERVICE MANUAL TRANSMISSIONS

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions:

Objective	Question
1	1, 2
2	3
3	4
4	6
5	5
6	7
7	8
8	9
9	10
10	11
11	12
12	13
13	14
14	15, 16
15A	17
15B	18
15C	19
15D	20
15E	21
15F	22
15G	23
15H	24
15I	25
15J	26
15K	27
15L	28
15M	29

ANSWER KEY

1. B
2. A
3. A
4. C
5. C
6. A
7. D
8. B
9. A
10. B
11. C
12. D
13. B
14. C
15. B
16. A
17. C
18. C
19. D
20. B
21. B
22. D
23. B
24. B
25. C
26. D
27. D
28. A
29. A

SERVICE MANUAL TRANSMISSIONS

NAME ______________________ SCORE ______

DIRECTIONS

Read the following questions and problems. Then put the letter of the item that best answers the question or solves the problem in the blank.

______1. A single part on which several gears of different sizes have been machined from a single piece of metal is a:

A. Sliding gear
B. Cluster gear
C. Constant mesh gear
D. Speed gear

______2. Sealing material used to form a tight seal between two parts is a:

A. Gasket
B. Snap ring
C. Thrust bearing
D. Washer

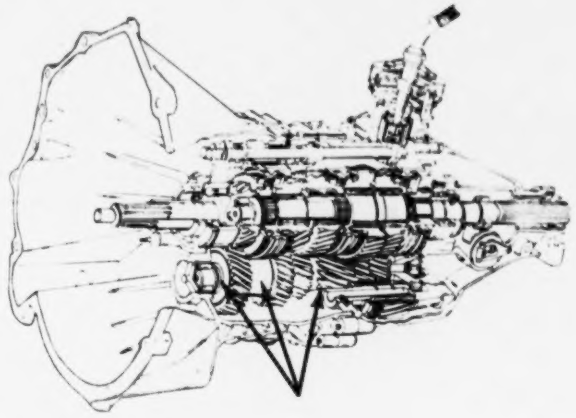
______3. If the driven gear is larger than the driving gear, the power will:

A. Increase
B. Decrease
C. Remain the same
D. Change as the speed changes

______4. The part of the transmission that allows the driver to change the transmission gear to adjust to different driving conditions is the:

A. Input shaft assembly
B. Output shaft assembly
C. Shift linkage
D. Countershaft assembly

______5. Which part of the transmission is shown?



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A. Input shaft
B. Output shaft
C. Countershaft
D. Reverse idler gear shaft

______6. Which of the following parts is commonly found attached to the outside of the transmission housing?

A. Back-up light switch
B. Synchronizer ring
C. Speedometer drive gear
D. Sliding gear

______7. What is usually found inside the input shaft gear?

A. A bushing
B. A snap ring
C. Gear teeth
D. Roller bearings

______8. The input shaft gear meshes with the:

A. Speed gear
B. Cluster input gear
C. Reverse idler gear
D. Sliding gear

______9. One of the ends of the output shaft is attached to the driveline. What holds the other end in place?

A. The input shaft
B. The pilot bearing
C. The synchronizer
D. The front bearing retainer

_____10. Clutch teeth are found on:

A. The clutch
B. A speed gear
C. A synchronizer
D. The reverse idler gear shaft

_____11. What part coordinates the speed of rotation between a speed gear and the output shaft?

A. The clutch
B. The reverse idler
C. The synchronizer
D. The rotor

_____12. The reverse idler gear meshes with a gear on the output shaft and one on the:

A. Reverse idler gear shaft
B. Input shaft
C. Axle shaft
D. Countershaft

_____13. If a car has a column gear shift, it has a(n):

A. Interior shift linkage
B. Exterior shift linkage
C. Shift rail linkage
D. Shift tower linkage

_____14. When the transmission is in first gear, how many transmission gears are carrying a power load?

A. 2
B. 3
C. 4
D. All of them

_____15. The test that is most helpful in diagnosing shift linkage problems is the:

A. Dynamic shift test
B. Static shift test
C. Road shift test
D. Physical inspection

_____16. Clicking or knocking coming from the transmission is probably caused by:

A. Broken gear teeth
B. A bad bearing
C. Low or incorrect transmission lubricant
D. Excessive end play in a transmission shaft

_____17. The purpose of a shifter adjustment pin is to:

A. Lengthen the shifter rods
B. Shorten the shifter rods
C. Hold the linkage rod levers in neutral during adjustment
D. Secure the linkage rods to each other

_____18. A crossmember is:

A. Another name for a transmission shaft
B. Part of the inside structure of a transmission housing
C. A steel support that holds the transmission to the vehicle frame
D. Part of a synchronizer

_____19. When you disassemble a transmission, it is unnecessary to:

A. Tag the bolts as to location of removal
B. Locate the transmission I.D. number
C. Shift the transmission into neutral
D. Get an assistant to help you

_____20. What part of an external shift assembly should be routinely replaced during a transmission overhaul?

A. Shift forks
B. O-rings
C. Detent spring
D. Bushings

_____21. When disassembling an internal shift linkage, Technician A says that shift forks can be matched with any shift rail. Technician B says that you should keep the shift forks and their shift rails together. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____22. Which is the best method for removing the bearing on the input shaft?

A. Pry it out with a screwdriver
B. Use a hammer and punch and drive it out from inside the housing
C. Remove it with snap ring pliers
D. Tap first on one side of the input shaft then on the other with a soft hammer

_____23. Which of the following statements is true about replacing transmission gears?

A. Replace only gears that are damaged or worn
B. If a gear is damaged, replace the damaged gear and the gear with which it meshes
C. If a gear is damaged, replace all the gears on that shaft
D. If a gear is damaged, replace all the gears in the transmission

_____24. A synchronizer sleeve is excessively worn. Technician A says you should replace the only the sleeve. Technician B says you should replace both the synchronizer sleeve and the synchronizer hub. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____25. A "dummy" shaft is used most often to remove and replace the:

A. Input shaft
B. Output shaft
C. Countershaft
D. Reverse idler gear shaft

_____26. Which shaft can be inspected while it is still installed in the transmission housing?

A. Input shaft
B. Output shaft
C. Countershaft
D. Reverse idler gear shaft

_____27. Technician A says that shaft end play in transmission shafts is always measured with a dial indicator. Technician B says that a feeler gauge should be always be used to measure this end play. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____28. Which of the following can be repaired on a transmission housing?

A. Stripped bolt threads
B. Cracks
C. Porosity
D. Deep scratches

_____29. Which of the following tasks should be done only **after** reinstalling the transmission in the vehicle?

A. Refill the transmission with the proper lubricant
B. Shift the gear shift through all gears
C. Check end play on the appropriate transmission shafts
D. Apply thread-locking compound to all transmission housing bolts

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive manual transmission by selecting the correct definition from four choices.

cluster gear — A single part on which several gears of different sizes have been machined from a single piece of metal

constant mesh gears — Gears which mesh at all times

foot-pound — A measure of torque which represents the amount of force required to lift one pound a distance of one foot

NOTE: Some torque measurements are made in inch-pounds—the amount of force required to lift one pound a distance of one inch. There are 12 inch-pounds in one foot-pound.

gasket — Sealing material used to form a tight seal between two parts

NOTE: Gaskets are often made of cork, paper, rubber, plastic, or soft metal. Sometimes a liquid sealant is painted on the surface and dries to form a flexible seal.

high gear — The transmission gear on the vehicle which produces the maximum road speed

low gear — The transmission gear on the vehicle which produces the slowest forward road speed

neutral — The position in the transmission that exists when all transmission gears are disengaged

overdrive — A gear ratio which allows the output shaft to turn faster than the input shaft

overhaul — A procedure in which an assembly is completely disassembled, cleaned, inspected, repaired, reassembled, and adjusted for proper operation

sliding gear — A gear which moves back and forth on its shaft to mesh with another gear or gears

snap ring — A spring steel ring containing an opening which allows it to fit over a shaft to hold parts in place

synchronize — To cause events to happen at the same time

torque multiplication — The increase in power which occurs when the driven gear is larger than the driving gear

OBJECTIVE 2 **Identify common driving situations which require greater torque and those which require less torque.**

COMMON DRIVING SITUATIONS

Require Greater Torque	Require Less Torque
Move the vehicle from a standing start	Keep the vehicle moving after it has established speed
Climb a hill	Go downhill
Drive on a rough road	Drive on a smooth road
Drive into a head wind	Drive with a tail wind
Carry a heavy load	Carry no extra load

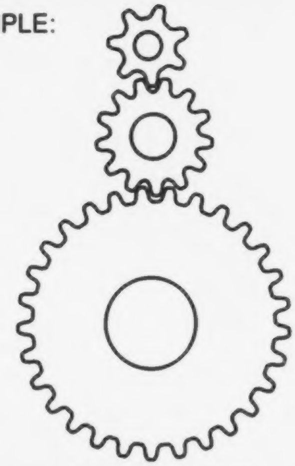
HOW THE TRANSMISSION INCREASES ENGINE TORQUE

The engine produces turning power (torque) to propel the vehicle. By depressing the accelerator pedal, the driver can make the engine turn the crankshaft faster or slower, but it cannot make each turn more powerful. It is the transmission which changes this *increased speed* into *increased power* to handle the needs of different driving situations.

The transmission increases the engine's torque by using gears. The basic concept is simple:

> **If the driven gear is larger than the drive gear, the power will be *increased* and the speed will be *decreased.***
>
> **NOTE:** This increase in power when the driven gear is larger than the drive gear is called ***torque multiplication***.
>
> **If the driven gear is smaller than the drive gear, the power will be *decreased* and the speed will be *increased.***
>
> **NOTE:** A driven gear which is smaller than the drive gear is called an ***overdrive gear***. A vehicle which has such a gear is said to have ***overdrive***—a gear ratio which allows the output shaft to turn faster than the input shaft. Many newer passenger vehicles have an overdrive gear—commonly the 4th or 5th forward gear (4th gear is not an overdrive gear on every vehicle). Use of overdrive allows the vehicle to save fuel *in situations which require less torque*. Using the overdrive gear in situations requiring greater torque not only uses more fuel than if the proper gear were used but causes excessive wear and damages the transmission.

EXAMPLE:



Smaller Driven Gear	Speed *increases* Power *decreases*	Turns 1.4 times (.70:1 gear ratio) 56 ft-lb torque
Drive Gear		Turns 1 time 80 ft-lb torque
Larger Driven Gear	Speed *decreases* Power *increases*	Turns .4 times (2.20:1 gear ratio) 176 ft-lb torque

If more power is needed so the vehicle can climb a hill or tow a trailer, shift the transmission so that the transmission's main drive gear contacts a gear larger than itself. The larger the gear contacted, the more power is available.

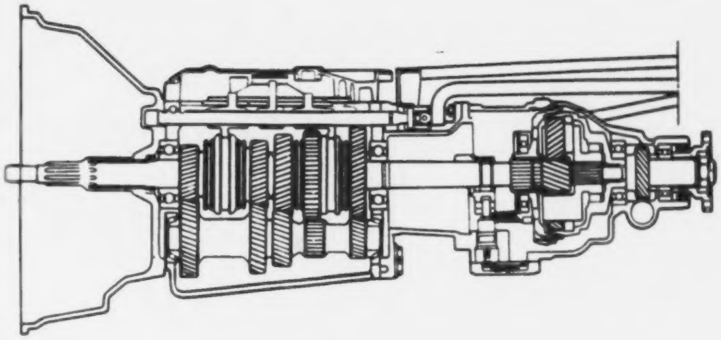
If you are driving at highway speeds on a flat, smooth highway, shift the transmission so the main drive gear contacts a gear smaller than itself. Less power is needed to keep the vehicle moving under these conditions. Each turn of the transmission input shaft will yield *more* than one turn of the output shaft—a real fuel saver!

TYPICAL GEAR RATIOS

5-Speed Transmission:		4-Speed Transmission:	
1st gear	3.79:1	1st gear	4.01:1
2nd gear	2.29:1	2nd gear	2.32:1
3rd gear	1.48:1	3rd gear	1.40:1
4th gear	1.00:1	4th gear	1.00:1
5th gear	0.79:1		
Reverse	3.90:1	Reverse	3.74:1

OVERDRIVE UNITS

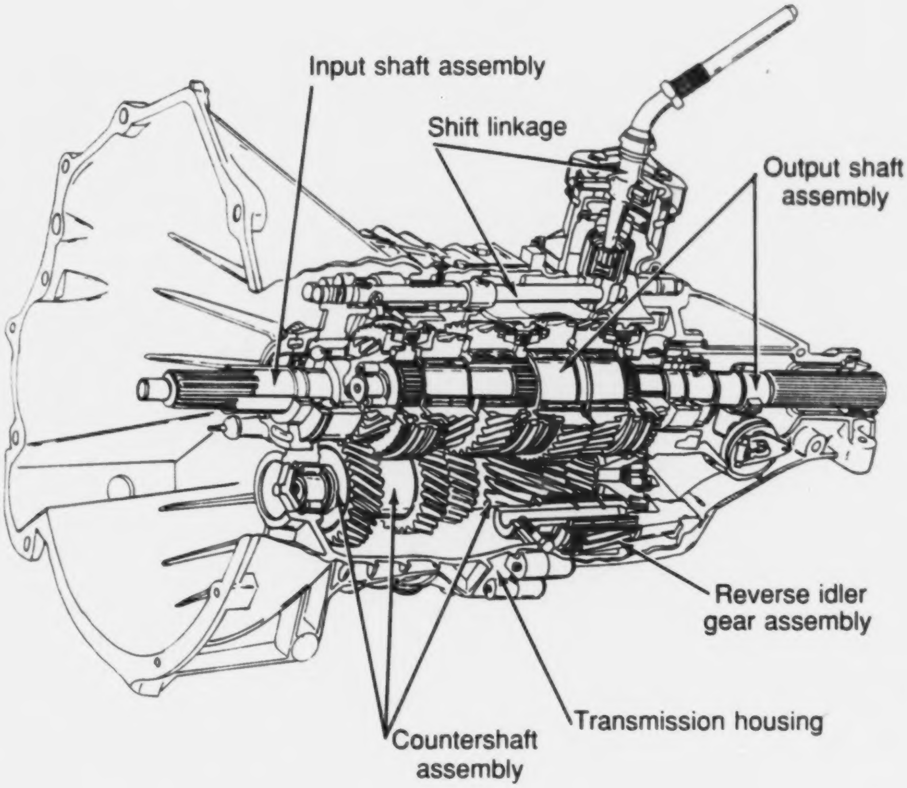
Some older vehicles have a *separate* overdrive unit attached to the transmission to allow overdrive gearing. Some newer vehicles are being equipped with separate overdrive units which allow overdrive gearing in all gears. The following illustration shows one of these units.



Courtesy of Volvo.

OBJECTIVE 3 **Label the basic parts of a transmission on an illustration.**

FIGURE 1


Input shaft assembly
Shift linkage
Output shaft assembly
Reverse idler gear assembly
Transmission housing
Countershaft assembly

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OBJECTIVE 4

Match the names of the basic parts of a transmission to a description of their functions.

Transmission housing — Protects the transmission and provides a mounting surface for transmission parts

Input shaft assembly — Accepts torque from the clutch and transfers it to the countershaft assembly

Countershaft assembly — Transfers torque to the reverse idler gear and all the gears on the output shaft

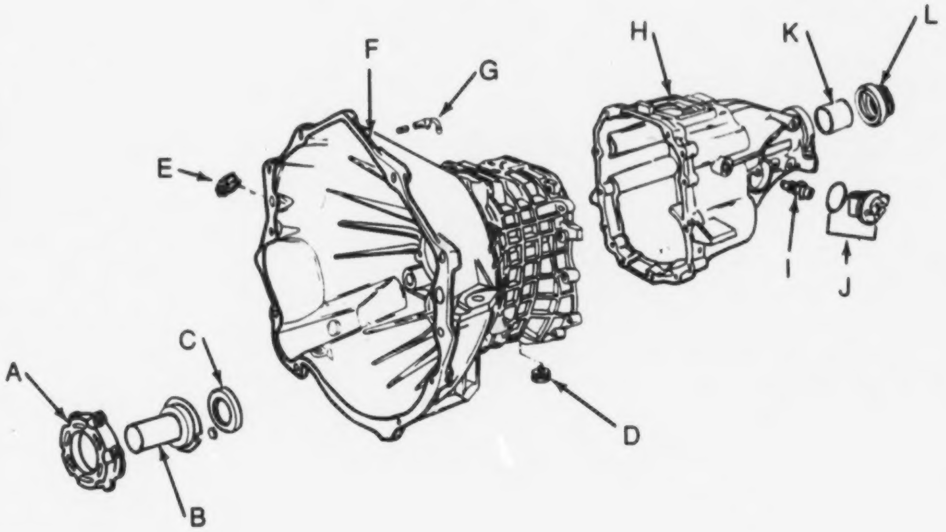
Output shaft assembly — The gears and synchronizers on this shaft increase or decrease the torque and transfer it to the vehicle's driveline

Reverse idler gear assembly — Changes the direction of the torque to allow the vehicle to move in reverse

Shift linkage — Allows the driver to change the transmission gear to adjust to different driving conditions

OBJECTIVE 5 **Match the names of the parts of a transmission housing to an illustration.**

FIGURE 2



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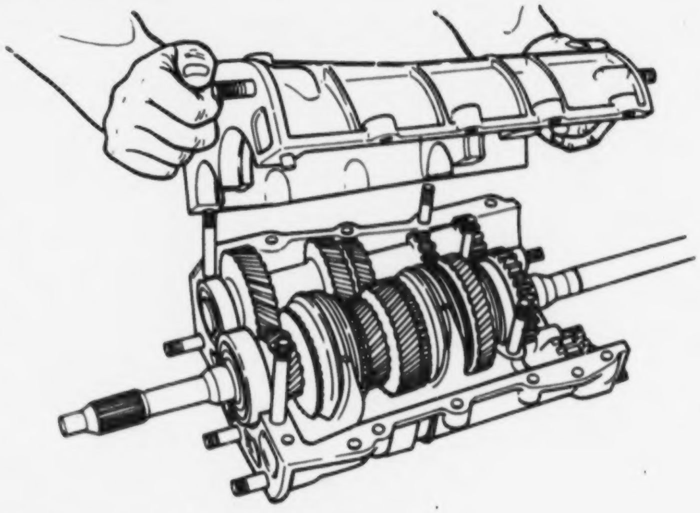
A	Input shaft bearing retainer	G	Vent
B	Retainer sleeve	H	Rear transmission housing
C	Input shaft oil seal	I	Back-up light switch
D	Oil drain plug	J	Speed sensor assembly
E	Oil fill plug	K	Rear bearing extension
F	Front transmission housing	L	Slip yoke oil seal

NOTE: Sometimes called a ***transmission case***, modern ***transmission housings*** are usually made of cast aluminum and come in a wide variety of designs. Some housings have an access cover through which the transmission components are inspected and removed. Other housings separate into two or more parts. Sometimes a removable metal wall called a ***center support plate*** comes between the sections and is used for mounting the interior components. Often special slopes and channels within the housing aid in keeping transmission components lubricated. The parts listed above are common on most transmissions.

NOTE: ***Split case transmission housings*** are found on some smaller vehicles.



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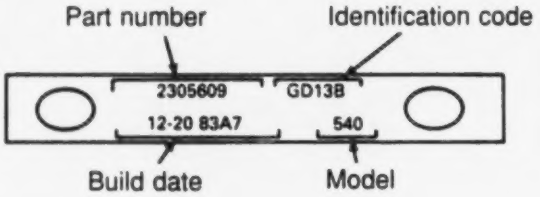
TRANSMISSION I.D. TAGS

Every manufacturer installs its own transmission design—and many use *several* designs. It is very important that you correctly identify the type of transmission in the vehicle *before* you attempt to remove it. The best way to do this is to locate the transmission identification number. This number may be stamped directly onto the transmission housing or it may be on a metal tag which is attached to a bolt hole on the housing. When you locate the transmission I.D. tag, use the vehicle's service manual to help you understand the information it contains. Be sure to replace the tag when you reassemble the transmission.



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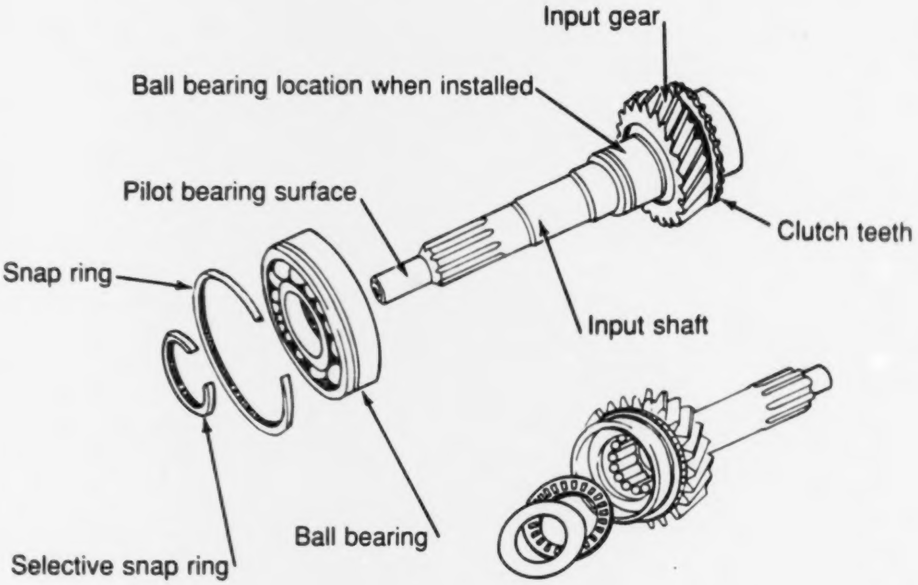
OBJECTIVE 6 **Label the parts of an input shaft assembly on an illustration.**

FIGURE 3


Input gear
Ball bearing location when installed
Pilot bearing surface
Clutch teeth
Snap ring
Input shaft
Ball bearing
Selective snap ring

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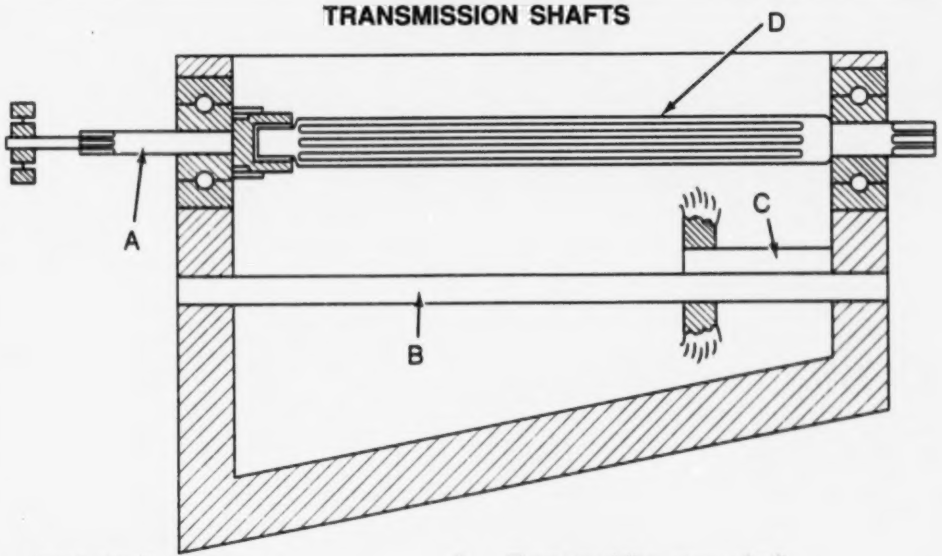
NOTE: The ***input shaft*** is also sometimes called the ***clutch shaft***, the ***main drive gear shaft***, or the ***pinion drive shaft***. The shaft itself, its helical input gear, and clutch teeth are machined from a single piece of steel. The forward end of the shaft fits into the pilot bearing in the crankshaft bore and the splined area meshes with the clutch disc. Input shaft end play is controlled by using a selective snap ring or shim on the outside of the input shaft's ball bearing. Needle or roller bearings fit inside the hollow input shaft gear and hold the end of the transmission output shaft. A ***selective snap ring*** is made of spring steel and unlike regular snap rings, comes in varying thicknesses to allow it to be used to control the position of the parts with which it is used.

TRANSMISSION SHAFTS

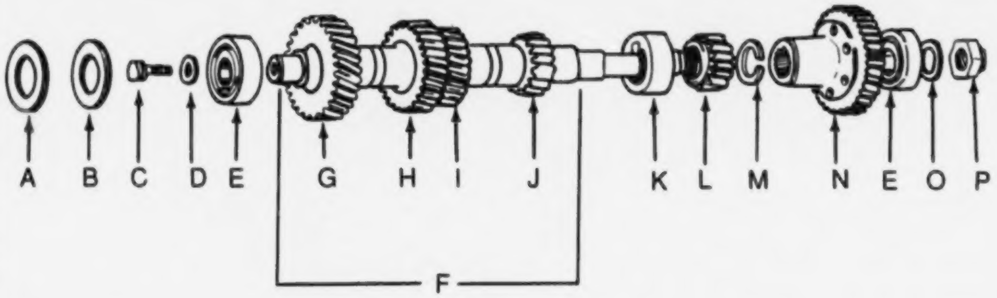


A	Input shaft	C	Reverse idler gear shaft
B	Countershaft	D	Output shaft

NOTE: There are four shafts in a manual transmission. Note that the end of the output shaft fits into the end of the input shaft gear, making these two separate shafts appear to be one.

OBJECTIVE 7 **Match the names of the parts of a countershaft assembly to an illustration.**

FIGURE 4



Used with permission of Toyota Motor Sales, U.S.A.

A	Shim
B	Thrust washer
C	Bolt with washer
D	Washer
E	Ball bearing
F	Cluster gear
G	Cluster input gear
H	Cluster gear 3rd gear
I	Cluster gear 2nd gear
J	Cluster gear 1st gear
K	Roller bearing
L	Countershaft reverse gear
M	Snap ring
N	Countershaft 5th gear
O	Shim
P	Nut

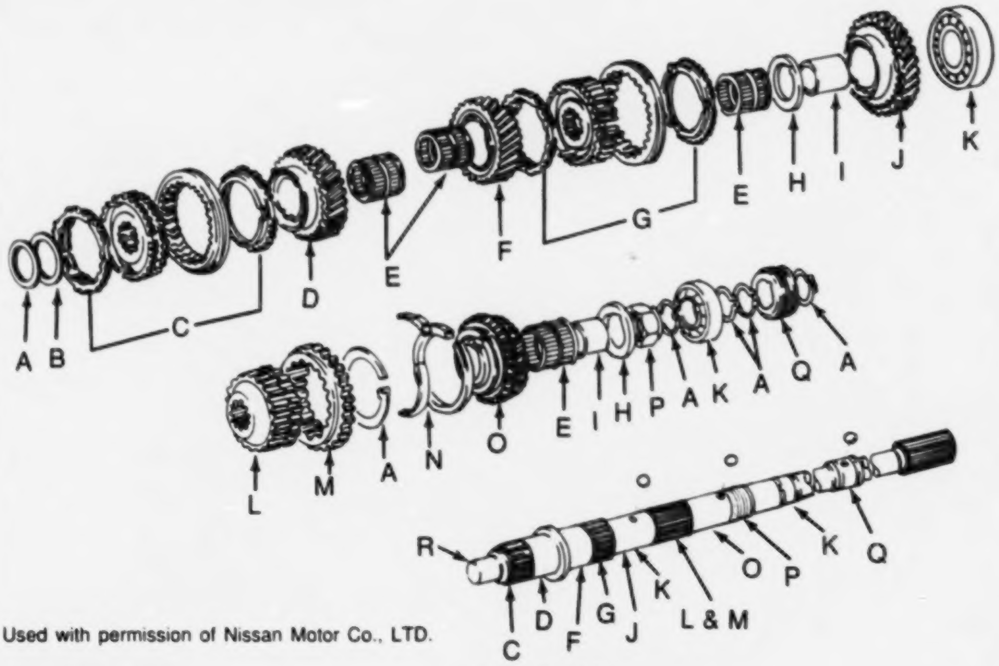
NOTE: On many vehicles, the ***countershaft*** and/or the gears on it are all machined from one piece of steel. A gear formed in this way is called a ***cluster gear***. A countershaft assembly can contain one or more cluster gears or individual countergears can be press fit to the countershaft. Countershaft gears mesh with the speed gears on the output shaft and the reverse idler gear on the reverse idler gear assembly. When the countershaft and its gears move through the transmission lubricant in the bottom of the transmission housing, they carry or splash lubricant to most of the other transmission gears and bearings. This is the main method of lubrication for the transmission.

CONSTANT MESH GEARS

All modern manual transmissions have ***constant mesh gears***—the gears on the countershaft are always in contact with the speed gears on the output shaft and the reverse idler gear. Gears on the output shaft of older vehicles were often splined to the output shaft and slid back and forth on the splines to contact the countershaft gears. This type of gear is called a ***sliding gear***. Reverse gear on modern vehicles is sometimes a sliding gear.

OBJECTIVE 8 | **Match the names of the parts of an output shaft to an illustration.**

FIGURE 5



Used with permission of Nissan Motor Co., LTD.

A	Snap ring
B	Washer
C	3rd & 5th gear synchronizer assembly
D	3rd gear
E	Caged needle bearings
F	2nd gear
G	1st & 2nd gear synchronizer assembly
H	Thrust washer
I	Bushing
J	1st gear
K	Ball bearing
L	Synchronizer hub
M	Sliding reverse gear
N	Synchronizer ring
O	5th gear
P	Output shaft nut
Q	Speedometer drive gear
R	Output shaft

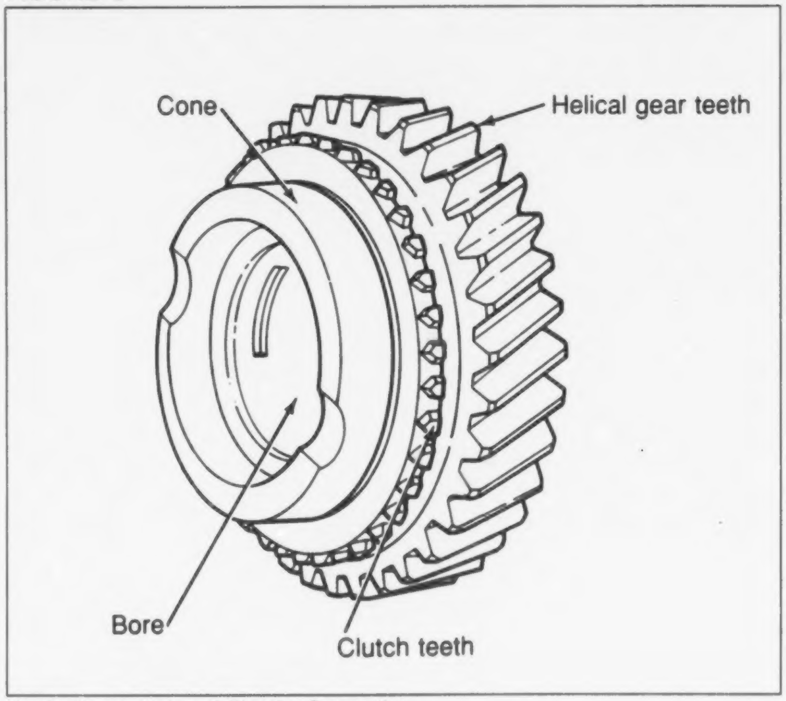
NOTE: Components on the ***output shaft***—sometimes called the ***mainshaft***—vary from model to model, but the components shown are commonly found. ***Speed gears***—gears on the output shaft which mesh with countershaft gears—rotate on needle bearings. ***Synchronizer assemblies*** between the speed gears engage the speed gears and transfer their rotation to the output shaft. (See Objectives 9 and 10 for a more complete look at these components.) Reverse gear is sometimes a spur gear whose straight gear teeth allow it to slide into contact with the gear on the reverse idler gear. A speedometer drive gear or a speed sensor monitors the speed of the output shaft, relaying this information to the speedometer inside the vehicle. Snap rings and thrust washers separate the parts of the output shaft and regulate output shaft end play.

COMMON TYPES OF TRANSMISSIONS

	Speed Gears	Overdrive Gear	Reverse Gear
3 SPEED	3	-	1
4 SPEED	3	1	1
4 SPEED	4	-	1
5 SPEED (most common)	4	1	1

OBJECTIVE 9 **Label the parts of a speed gear on an illustration.**

FIGURE 6



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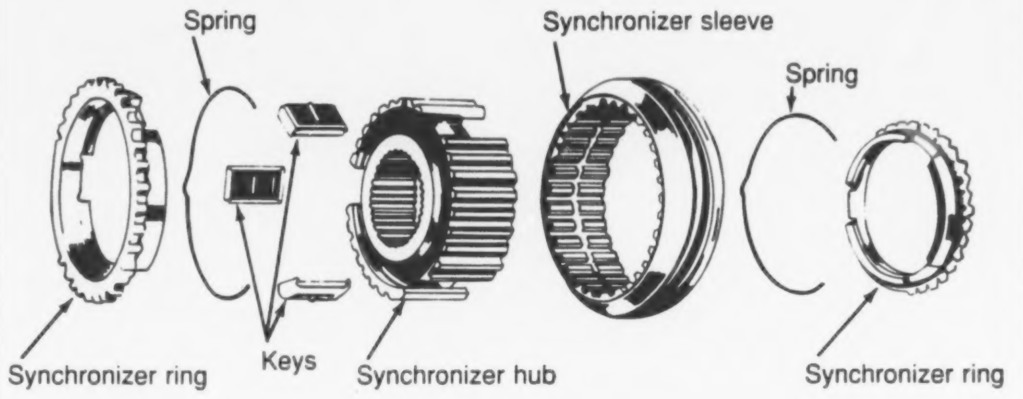
NOTE: The ***speed gear's*** helical gear teeth mesh with a corresponding gear on the countershaft. The ***cone*** and ***clutch teeth*** on one side of the speed gear are design features which allow the gear to mesh with the synchronizer. The bore of the speed gear does not fit directly on the output shaft as might be expected. Instead, needle bearings between the speed gear and the output shaft allow the speed gear to rotate independently of the output shaft. The speed gear's ability to always rotate with the countershaft regardless of the direction of the output shaft is very important when the transmission is in neutral or reverse.

OBJECTIVE 10 **Label two types of synchronizer assemblies and their parts on illustrations.**

KEY TYPE SYNCHRONIZER

FIGURE 7



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PARTS OF A KEY TYPE SYNCHRONIZER

When the transmission gears are shifted, it is the ***synchronizer assembly*** which coordinates the speed of rotation between a speed gear and the output shaft and joins them together so that the rotating gear can turn the shaft. The synchronizer is usually identified in relation to the gear or gears it coordinates. For example the synchronizer used for 1st and 2nd gear may be called the "1st and 2nd speed synchronizer."

The ***synchronizer hub*** is splined to the output shaft on one side and the ***synchronizer sleeve*** on the other. Special alignment marks on the synchronizer hub and sleeve insure that they fit together correctly. Small ***keys*** in the outside perimeter of the synchronizer hub fit between the hub and the sleeve, and a small ridge on their surface centers the sleeve on the hub. (Note the groove in the middle of the synchronizer sleeve bore on the illustration.) A ***spring*** which fits inside the edge of the hub holds the keys in place.

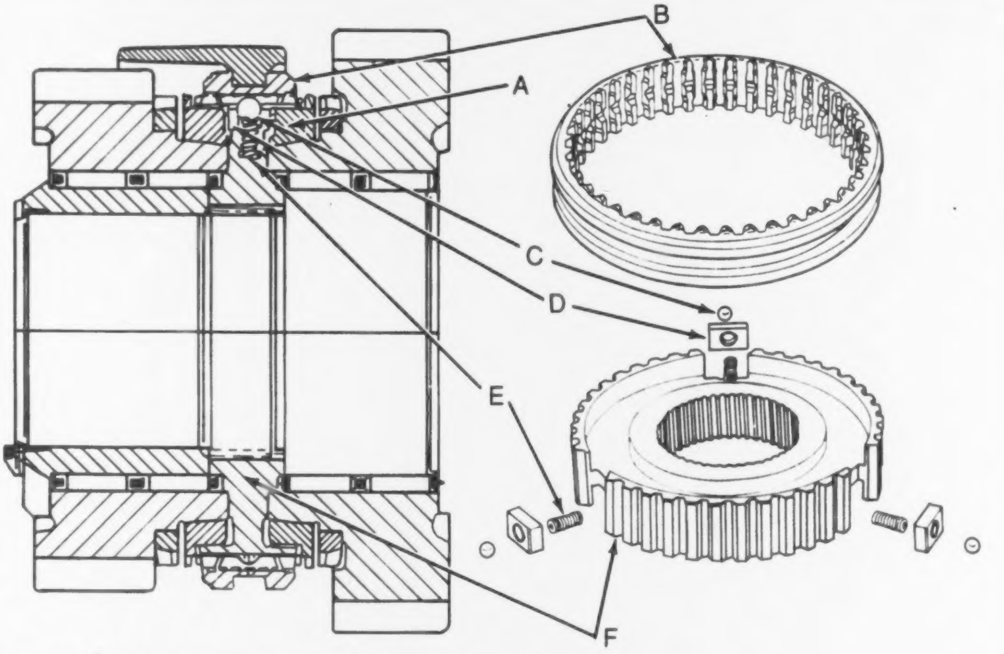
PARTS OF A KEY TYPE SYNCHRONIZER
Continued

A ***synchronizer ring*** is located between the main synchronizer assembly and the gear which the synchronizer assembly engages. If the synchronizer is used for gears on both sides of the central assembly, there are synchronizer rings on both sides. The synchronizer ring has tiny sharp grooves in its bore where the bore meets the speed gear cone. These grooves cut through the thick transmission fluid which normally coats the cone, allowing the synchronizer and the speed gear to fit together.

Term:	**Sometimes called:**
Synchronizer assembly	*Synchronizer clutch* or *synchro*
Synchronizer sleeve	*Clutch sleeve* or *outer sleeve*
Keys	*Struts, detents*, or *inserts*
Springs	*Energizer springs, insert springs*, or *detent springs*
Synchronizer rings	*Blocker rings, blocking rings*, or *stop rings*

BALL TYPE SYNCHRONIZER

FIGURE 8



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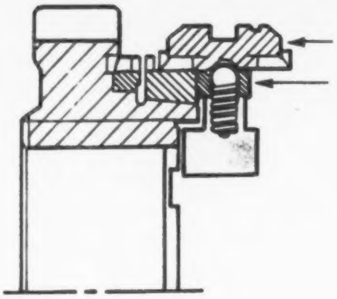
A Synchronizer ring
B Synchronizer sleeve
C Ball
D Key
E Spring
F Synchronizer hub

HOW A SYNCHRONIZER WORKS

When the driver wants to shift gears, the clutch is disengaged, and the input shaft, disconnected from the engine's torque, slows down within a few seconds. When the input shaft slows down, the countershaft and the speed gears also slow down. However because of the inertia of the forward motion of the vehicle, the output shaft and the synchronizers which are splined to it maintain much of their rotation. It is the job of the synchronizer to coordinate the speed of the output shaft and the speed gear and then join the two so that, when the clutch reconnects the engine's torque, the power will flow through the speed gear the driver has selected.



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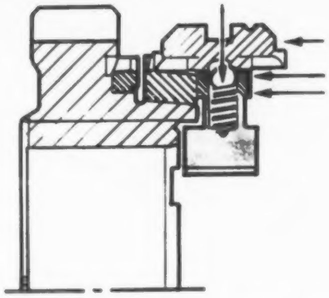
1. As the shift fork begins to move the synchronizer sleeve toward the synchronizer ring, the key presses the synchronizer ring against the speed gear, increasing the rotation of the speed gear so the synchronizer assembly and the gear can mesh. The springs still push the ball firmly in the central groove of the synchronizer sleeve, holding the synchronizer sleeve and hub together.



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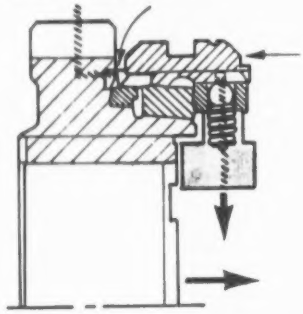
2. When the shift fork pushes the sleeve further, the sleeve presses against the ball, which compresses the springs, allowing the synchronizer sleeve to slide on the synchronizer hub. The teeth on the synchronizer sleeve begin to mesh with those on the synchronizer ring. The continued pressure of the key against the synchronizer ring and the speed gear has caused them to rotate at the same speed.



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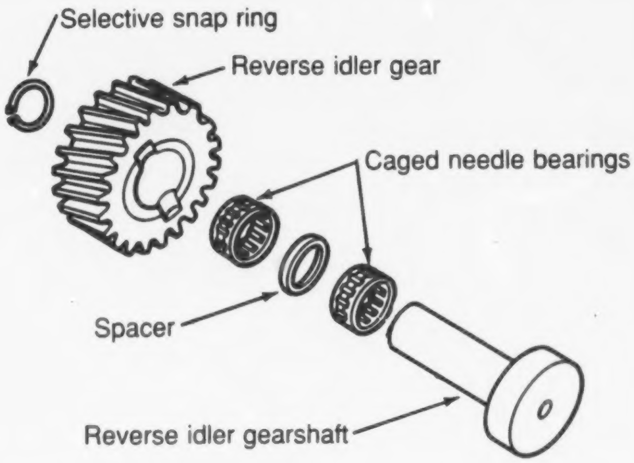
3. The synchronizer sleeve, already meshed and rotating with the teeth on the synchronizer ring, moves closer to the speed gear, and its teeth mesh with the clutch teeth on the speed gear. Because the synchronizer sleeve is meshed with both the clutch teeth on the speed gear and the splines on the synchronizer hub, the rotation of the speed gear is immediately transferred to the output shaft.

OBJECTIVE 11 **Label the parts of a reverse idler gear assembly on an illustration.**

FIGURE 9


Selective snap ring
Reverse idler gear
Caged needle bearings
Spacer
Reverse idler gearshaft

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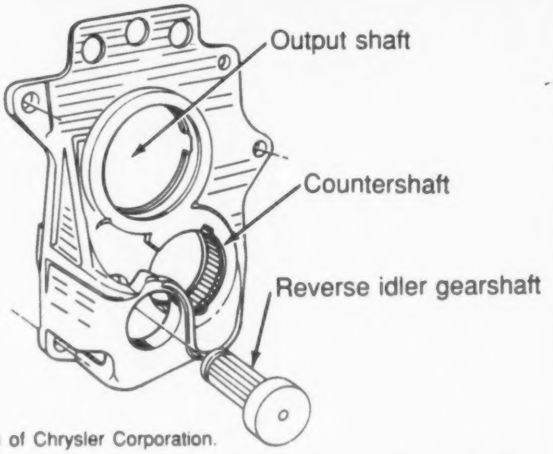
NOTE: The reverse idler shaft is aligned parallel to the countershaft and the output shaft. It is supported by a center support plate or the transmission housing on one end and a built-in support in the housing on the other.


Output shaft
Countershaft
Reverse idler gearshaft

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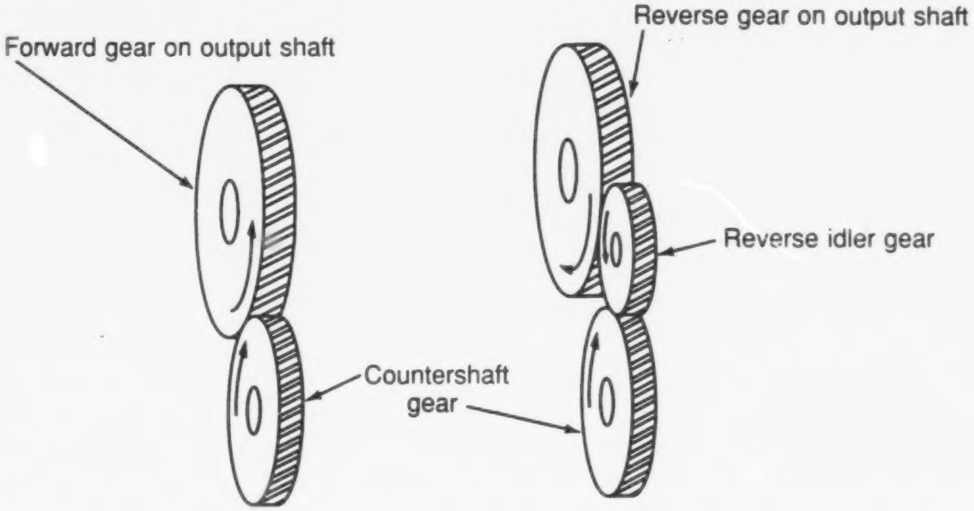
HOW THE REVERSE IDLER ASSEMBLY CHANGES THE DIRECTION OF THE OUTPUT SHAFT ROTATION

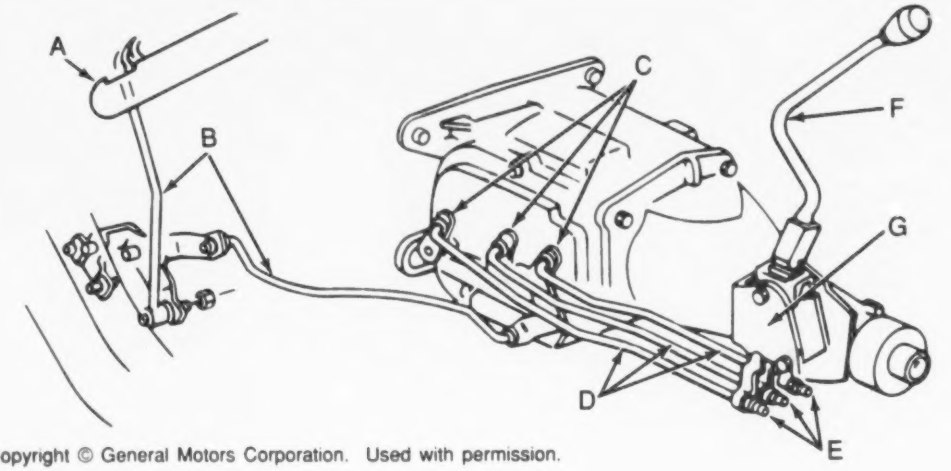
Unlike other transmission gears, the reverse idler gear meshes with *two* other gears—the reverse gear on the countershaft and the reverse gear on the output shaft. Adding a third shaft between the countershaft and the output shaft changes the direction of the torque reaching the output shaft. All the gears on the output shaft always rotate in the same direction *except* the reverse gear—it always rotates in the opposite direction.


Forward gear on output shaft
Reverse gear on output shaft
Reverse idler gear
Countershaft gear

OBJECTIVE 12 **Label the two types of transmission shift linkages and match the names of their basic parts to illustrations.**

EXTERNAL SHIFT LINKAGE

FIGURE 10



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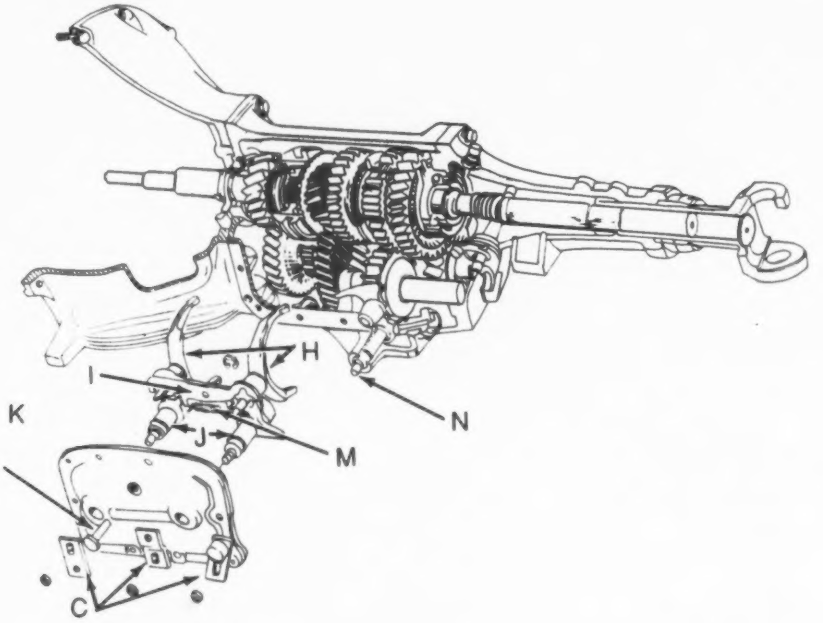

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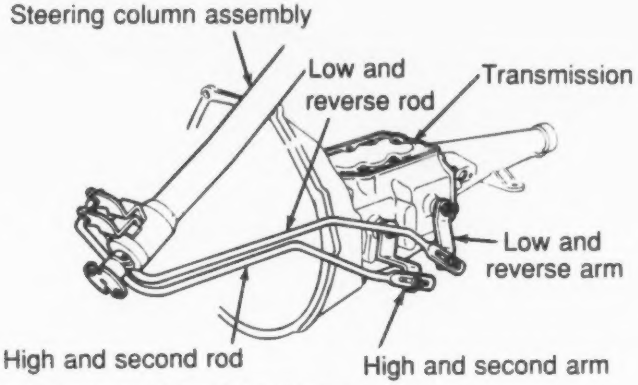
A	Steering column	H	Shift forks
B	Transmission lock rod	I	Detent cams
C	Shifter arms	J	Shifter shafts
D	Shift linkage rods	K	Shift cover
E	Linkage rod levers	L	Detent cam shaft
F	Gear shift lever	M	Detent spring
G	Gear shift lever bracket	N	Shifter shaft for reverse

NOTE: ***External shift linkages*** have the linkage from the gear shift lever to the transmission mounted outside the transmission housing. The external shift linkage pictured is for a 4-speed floor-mounted transmission linkage. When the driver selects a transmission gear, he moves the gear shift lever into the position appropriate for that gear. This motion is carried through the linkage rod levers and shift linkage rods to the shifter arms on the side of the transmission housing. Each shifter arm usually has three positions. In the central position the shift fork inside the transmission moves the synchronizer to a neutral position between the two speed gears it controls. If the shifter arm is moved forward or back, the shift fork moves the synchronizer to engage one or the other of the speed gears located on either side.

COLUMN MOUNTED EXTERNAL SHIFT LINKAGE

Column mounted external shift linkages are usually found on 3-speed transmissions.


Steering column assembly
Low and reverse rod
Transmission
Low and reverse arm
High and second rod
High and second arm

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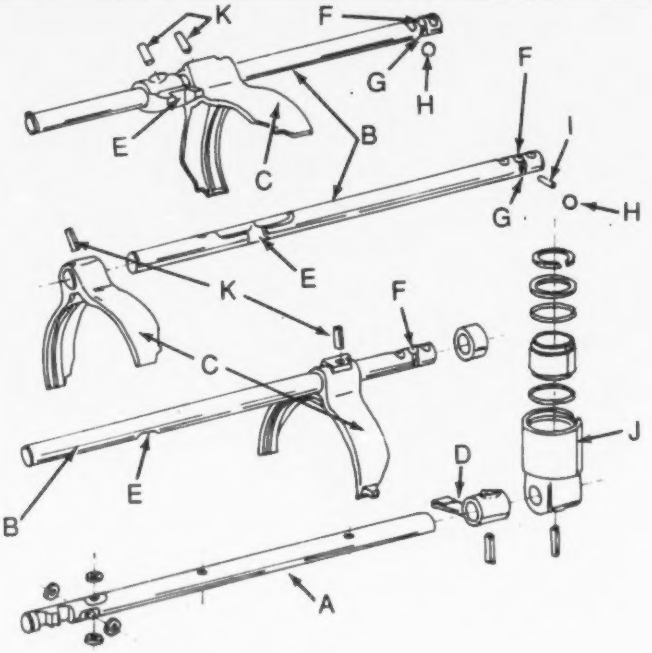
INTERNAL SHIFT LINKAGE

FIGURE 11



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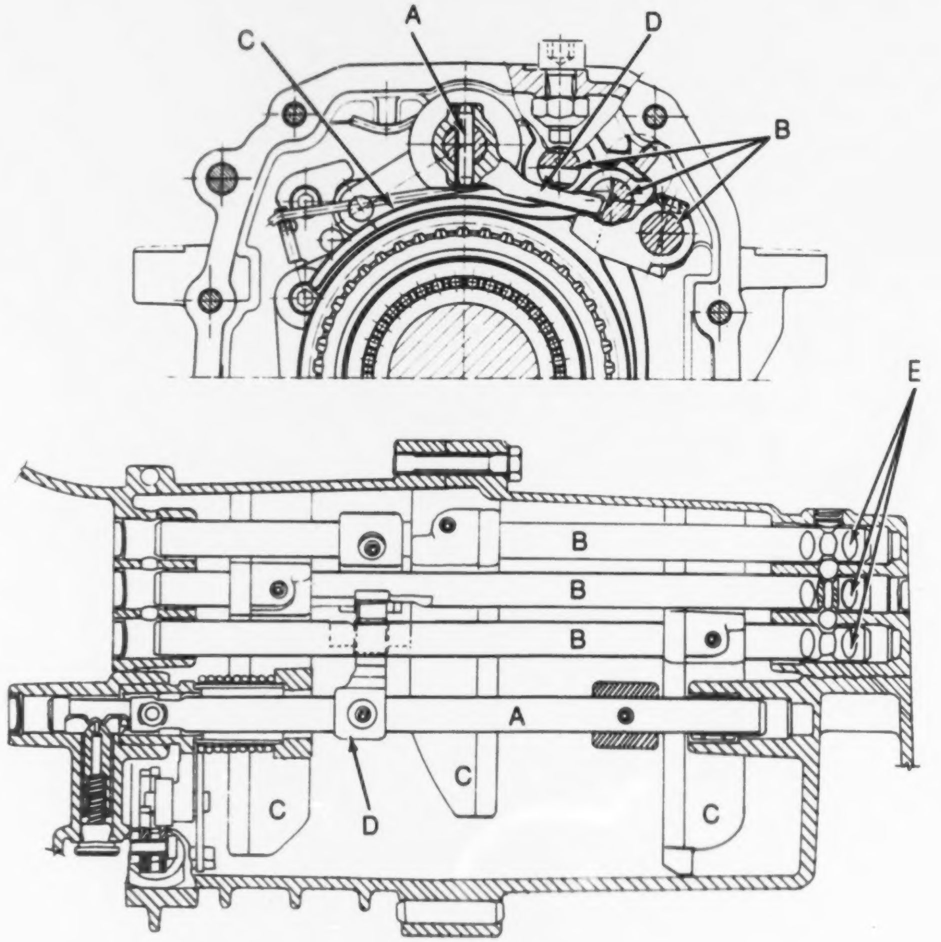
A	Shift shaft	F	Notch for shift detent ball
B	Shift rail	G	Notch for interlock balls
C	Shift fork	H	Interlock ball
D	Shift shaft finger	I	Interlock pin
E	Notch contacted by shift shaft finger to move shift fork	J	Gear shift lever tower
		K	Drift pin

NOTE: ***Internal shift linkages*** are always floor mounted and have the linkage from the gear shift lever to the transmission mounted inside the transmission housing. The internal shift linkage pictured is for a 5-speed transmission. The gear shift lever extends directly into the transmission housing and moves the shift shaft. Moving the gear shift lever from side to side rotates the shift shaft, allowing it to contact one of three shift rails with its shift shaft finger. When the shift shaft finger contacts the desired shift rail, the driver moves the gear shift lever forward or back. The shift fork attached to that shift rail will move the synchronizer to mesh with the appropriate speed gear.

HOW THE INTERNAL SHIFT LINKAGE FITS IN THE TRANSMISSION HOUSING



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A	Shift shaft	D	Shift shaft finger
B	Shift rail	E	Notch for shift detent ball
C	Shift fork		

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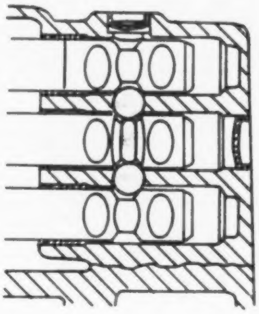
SHIFT INTERLOCK MECHANISM

The ***shift interlock mechanism*** on an internal shift linkage is both very simple and very important. Two balls fit into notches cut in the sides of the three shift rails, and a small pin fits into a hole drilled into the middle rail. When the shift rails are all in neutral, the balls sit between the rails with plenty of room. (See illustration A.)

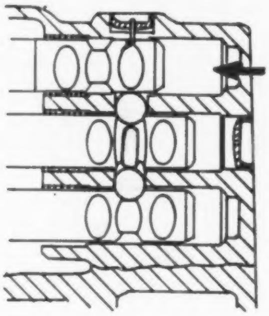
When one of the rails is moved forward or back, the ball next to that rail moves out of the notch on the moving rail and is crowded into the notch on the rail next to it. This crowding pushes the interlock pin into the space on the opposite side, and the pin, the two balls, and the two remaining rails are *locked* into place, unable to move. (See illustration B.)

When the middle rail moves forward or back, the balls next to the rails on either side are squeezed into the notches on the stationery rails—again locking the rails into place. (See illustration C.)

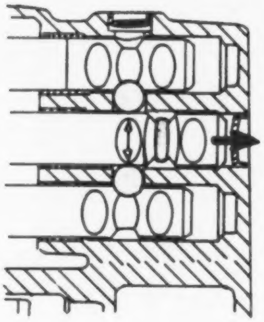
In this way, the shift interlock mechanism keeps the transmission from accidently shifting into two gears at the same time.



A



B



C

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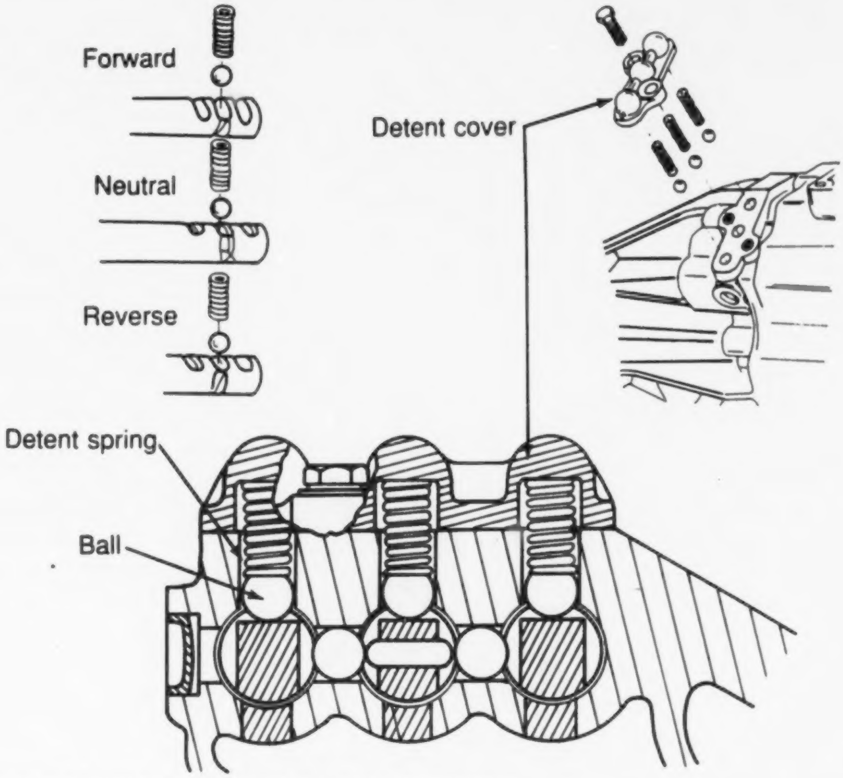
HOW A DRIVER CAN "FEEL" WHETHER HE HAS SHIFTED CORRECTLY

When the shift shaft moves a shift rail forward and back, a shallow notch in the shift rail will move directly under a small ball which is held in place by a spring. Each shift rail has three such notches—for neutral, forward, or rearward shift motions. "Feeling" the notch move under the balls tells the driver that he has shifted correctly.


Forward
Detent cover
Neutral
Reverse
Detent spring
Ball

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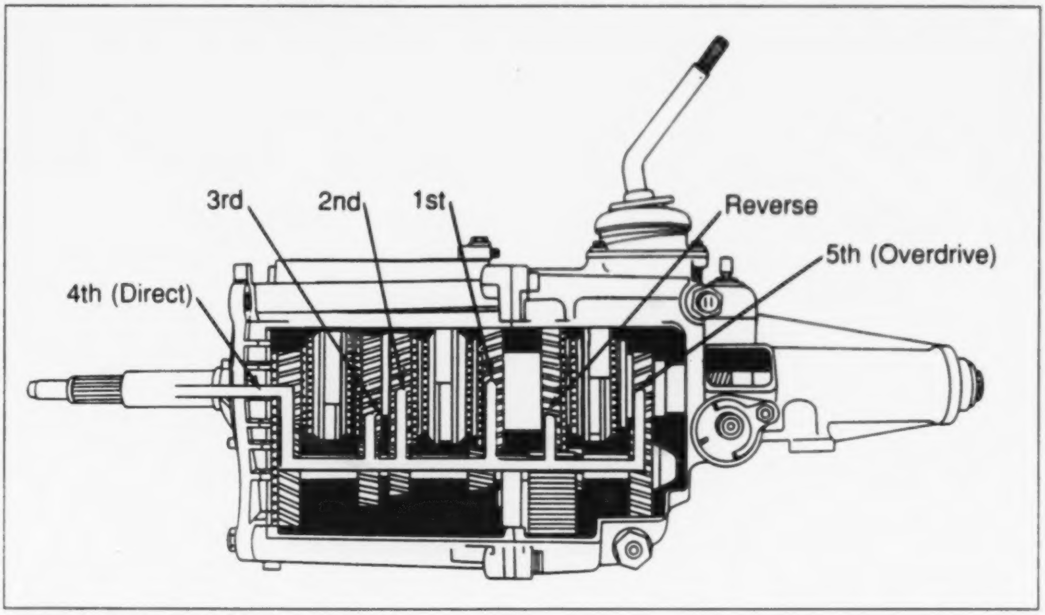
OBJECTIVE 13 **Trace the flow of power through each gear setting on illustrations of a five-speed transmission.**

NOTE: When the vehicle's engine is running and the clutch is engaged, an observer would see that ***all*** of the transmission gears are rotating, *regardless of which gear the transmission is in*. However, although they are all moving, ***ONLY A FEW of the gears are actually involved in turning the output shaft***. Most gears are rotating idly on their bearings as a result of the constant mesh arrangement. The transmission's ***power flow*** follows a separate path for every forward gear, reverse, and neutral. The following charts do not show which gears are turning—they're all turning. The charts show which gears are involved in delivering the power flow that is operating the vehicle.

NEUTRAL

FIGURE 12



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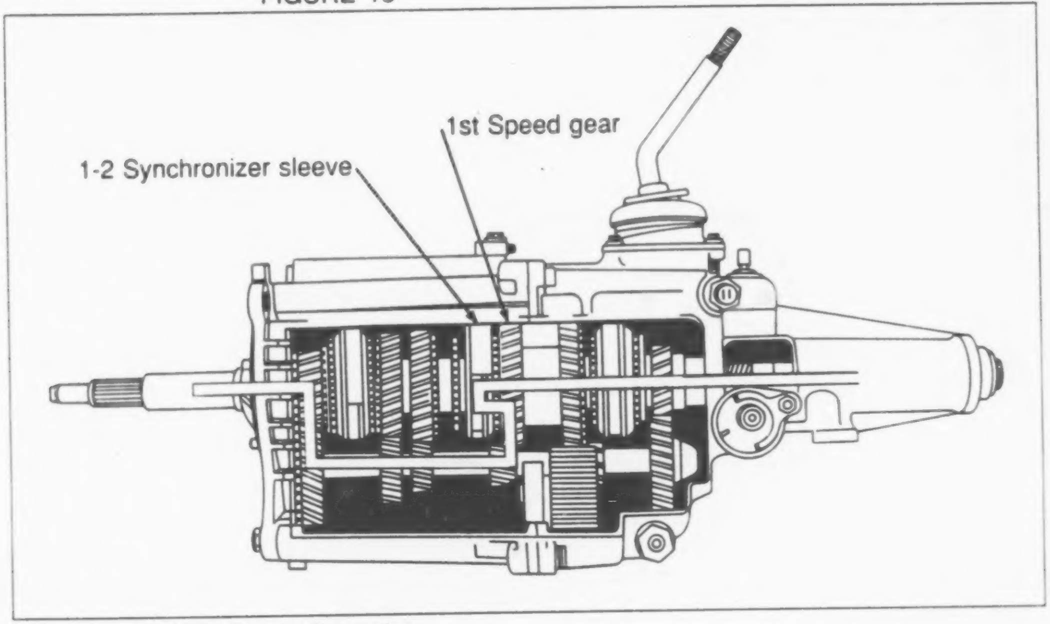
1ST GEAR

FIGURE 13


1st Speed gear
1-2 Synchronizer sleeve

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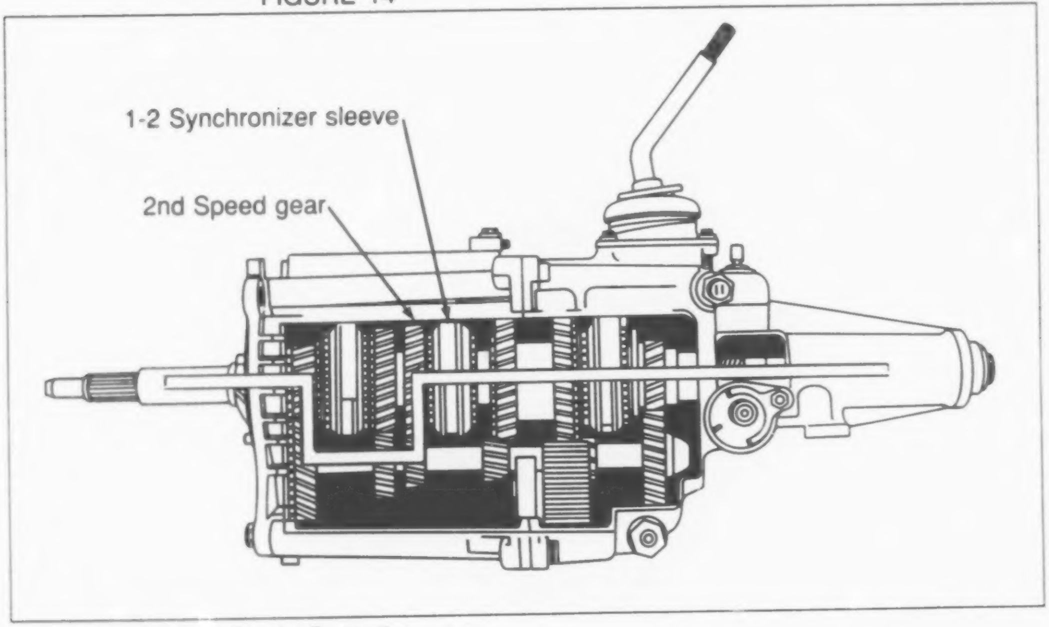
2ND GEAR

FIGURE 14


1-2 Synchronizer sleeve
2nd Speed gear

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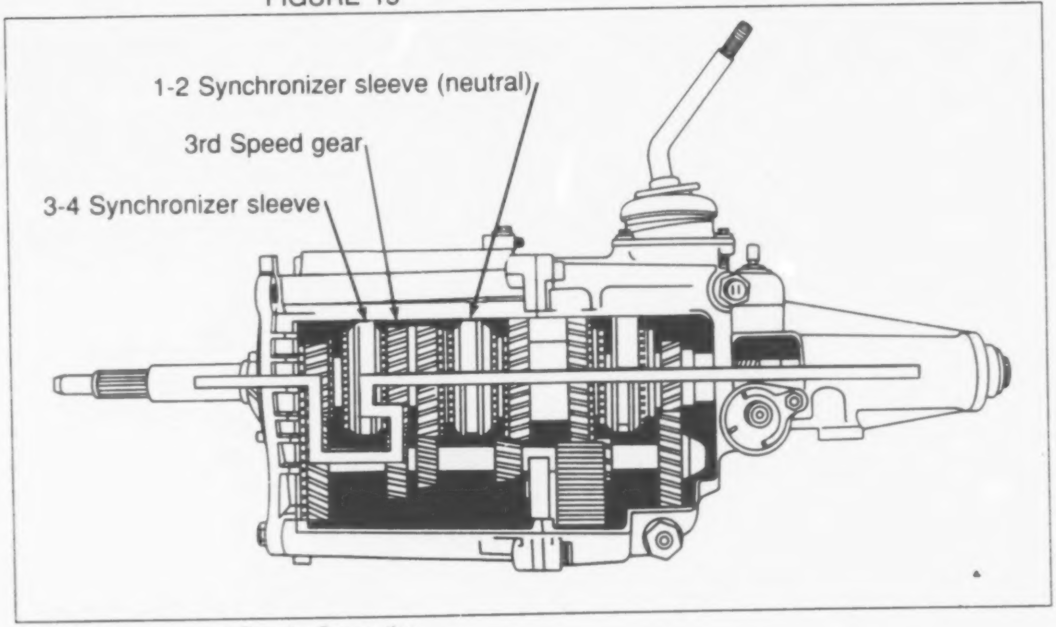
3RD GEAR

FIGURE 15


1-2 Synchronizer sleeve (neutral)
3rd Speed gear
3-4 Synchronizer sleeve

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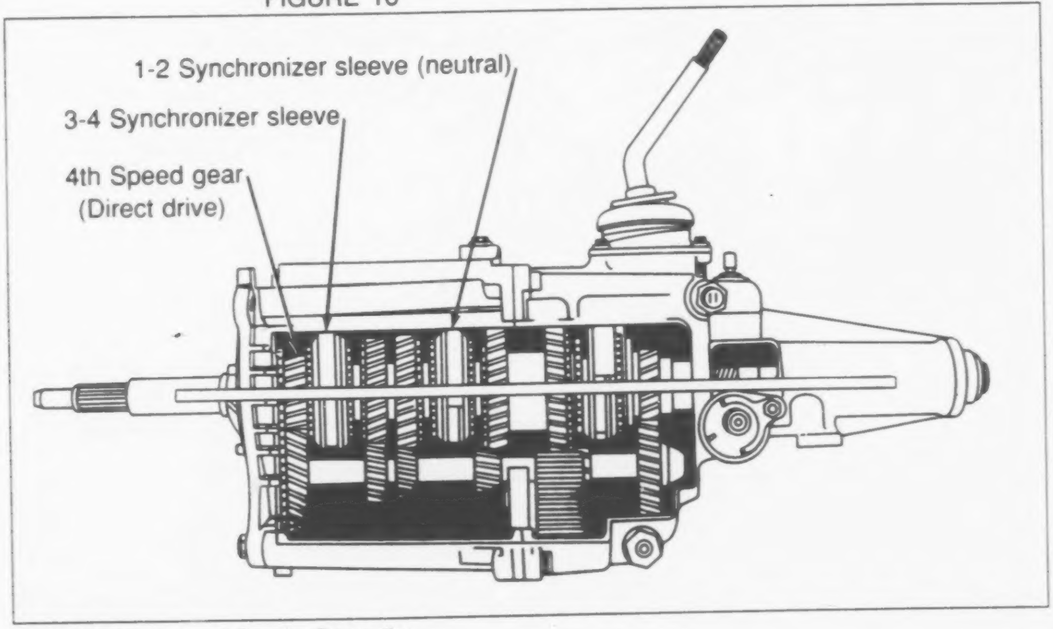
4TH GEAR

FIGURE 16


1-2 Synchronizer sleeve (neutral)
3-4 Synchronizer sleeve
4th Speed gear
(Direct drive)

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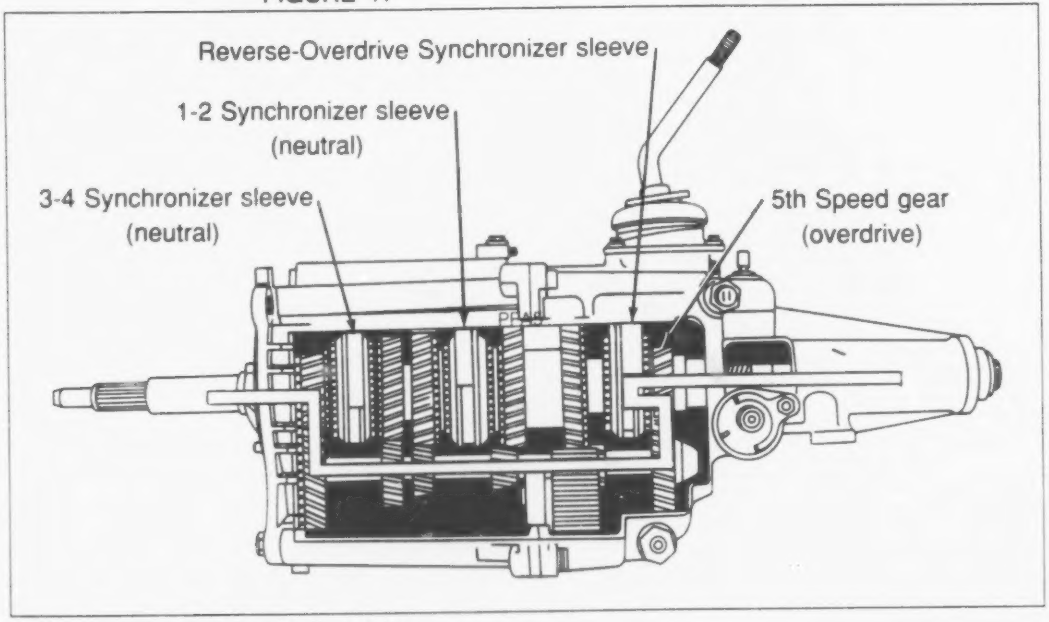
5TH GEAR

FIGURE 17


Reverse-Overdrive Synchronizer sleeve
1-2 Synchronizer sleeve (neutral)
3-4 Synchronizer sleeve (neutral)
5th Speed gear (overdrive)

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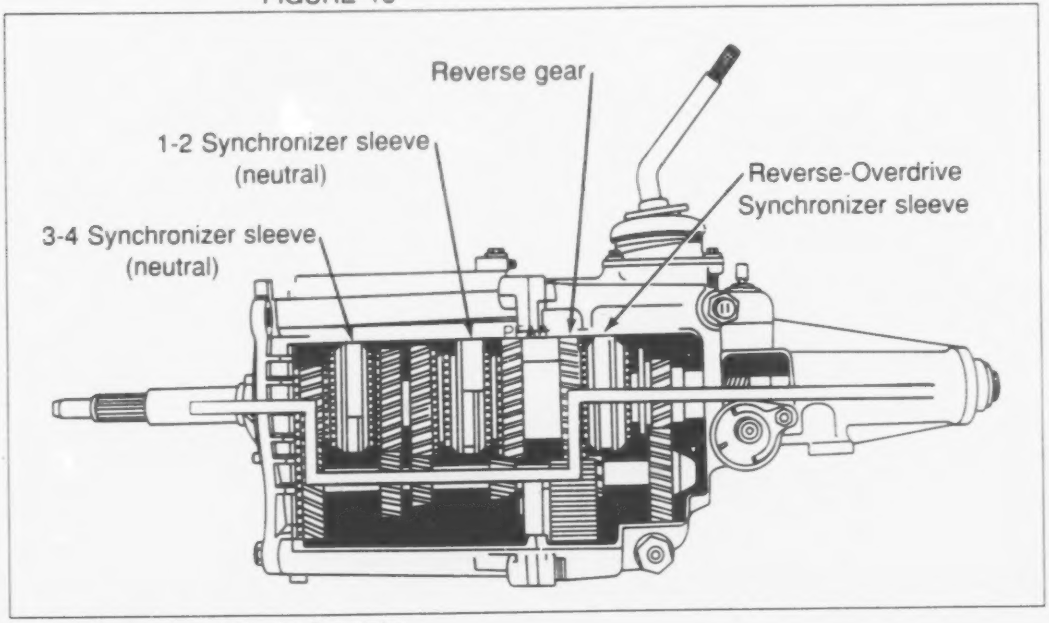
REVERSE

FIGURE 18


Reverse gear
1-2 Synchronizer sleeve (neutral)
Reverse-Overdrive Synchronizer sleeve
3-4 Synchronizer sleeve (neutral)

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TRANSMISSION TROUBLESHOOTING GUIDE

In addition to the vehicle's service manual, use Supplements 2, 3, and 4, ***Transmission Performance Diagnosis Chart***, ***Transmission Noise Diagnosis Chart***, and ***Transmission Leak Diagnosis Chart***, to assist in diagnosing transmission problems. You will also need Supplements 1-4, Unit 3, to help you evaluate the possibility of transmission problems that are clutch-related.

1. **Talk to the vehicle's owner.** The first step in diagnosing any automotive problem is to talk to the vehicle's owner about the nature of the problem and the service history of the vehicle. What problems are there in shifting? What gears are noisy? Under what conditions?

2. **Make a static shift test.** A static shift test helps find problems with the shift linkage. Follow these steps:

   (1) Do not turn on the engine during this test.
   (2) Press down on the clutch pedal.
   (3) Shift the transmission into a gear setting.
   (4) Release the clutch pedal.
   (5) Shift the transmission into each of the other gear settings.
   (6) Notice:
      - Unusual noises
      - Excessive shift effort

3. **Road test the vehicle to verify the problem.** Use Supplement 3, Unit 1, "Making a Diagnostic Road Test," and road test the vehicle. Make sure the transmission fluid level is correct and warm up the transmission before you begin. Drive in a quiet area and try to reproduce the problems described to you by the owner. The purpose of this first road test should be to verify the problem and to try to make sure any noise you hear is coming from the transmission and not from some other part such as the tires, fan belt, or engine.

   If you believe the problem is in the transmission, shift into each gear in turn. Drive in each gear while speeding up and while slowing down. Watch for the following performance problems:

   - Slipping or jumping out of gear
   - Hard shifting
   - Gears clashing when shifting
   - Sticking in a gear
   - Cannot be shifted out of a gear
   - Cannot be shifted into a gear
   - No power through the transmission

Listen for transmission noise. Do you hear it when the vehicle is in neutral? When it is in gear? Which gear? Use the vehicle's service manual and/or Supplements 2 and 3, "Transmission Performance Diagnosis Chart," and "Transmission Noise Diagnosis Chart," to form a possible diagnosis.

Once you have verified the condition, ask yourself this question: Can this problem be caused by anything other than a transmission problem? If so, explore and eliminate those possibilities. Disassembling a transmission is time-consuming and expensive.

4. **Inspect the transmission.** By making an external examination, you can eliminate several simple causes of transmission problems.

    - Examine the transmission mounts for damage or wear.
    - If the transmission has an external shift linkage, examine it for wear, damage, and proper alignment.
    - Check the transmission case for damage.
    - Check for transmission fluid leaks. Remember that as the vehicle moves, the transmission fluid from a leak will blow towards the rear of the vehicle. Refer to the vehicle's service manual and use Supplement 4, "Transmission Leak Diagnosis Chart," to help you diagnose the source of the leak.

5. **Eliminate the possibility of clutch problems.** Use Supplement 2, Unit 3, "Clutch Troubleshooting Guide" to see if the vehicle has clutch problems that could be causing transmission problems.

6. **Repeat the road test and make your final diagnosis.** Repeat your road test, shifting through all gears. Listen for transmission noise. Use the vehicle's service manual to help you evaluate the results of the tests you have made and identify the probable causes of transmission noise and performance problems.

7. **Disassemble, inspect, and repair or replace the transmission.** Because disassembling the transmission is a time-consuming, therefore expensive, task, you will want to use your diagnostic charts to insure that such action is actually necessary before you remove the transmission. Most technicians inspect and evaluate the clutch components at the same time they remove the transmission to assure that transmission problems are not clutch-related. Make sure you cure the cause of the problem, not just the symptom.

TRANSMISSION PERFORMANCE DIAGNOSIS CHART

Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transmission jumps or slips out of gear	Worn, loose, or binding shift linkage	Repair and adjust shift linkage
	Excessive end play in a transmission shaft	Correct end play
	Worn or broken synchronizer	Replace synchronizer
	Worn or damaged shift fork, lever, shaft, and/or other linkage part	Replace worn or damaged parts
	Worn clutch teeth on input shaft gear	Replace input shaft
	Loose or damaged input shaft bearing retainer	Replace and/or tighten bearing retainer
	Loose or misaligned clutch housing and/or transmission case	Align and tighten clutch housing and/or transmission case
	Stiff shift lever seal	Replace seal
	Bent output shaft	Replace output shaft
	Bad rail detent springs	Replace rail detent springs
	Worn synchronizer ring clutch teeth	Replace synchronizer ring
	Worn speed gear teeth	Replace speed gear
	Worn bearings	Replace bearings
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing
	Excessive crankshaft end play	Correct crankshaft end play

TRANSMISSION PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transmission shifts hard	Transmission fluid too thick due to cold	Warm vehicle
	Low or wrong transmission lubricant	Fill with correct lubricant
	Shift linkage needs lubrication, repair, or adjustment	Lubricate, repair, or adjust shift linkage
	Improper clutch pedal free travel adjustment	Adjust free travel
	Dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Worn, damaged, binding, or improperly installed synchronizer assembly	Service or replace synchronizer assembly
	Binding synchronizer rings or sliding gear	Replace synchronizer rings, sliding gears, or output shaft
	Loose or misaligned clutching housing and/or transmission case	Align and tighten clutch housing and/or transmission case
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Worn or binding shift forks, levers, or rails	Replace or service shift forks, levers, or rails
	Improper functioning of internal shift linkage	Check and service internal shift linkage
	Worn or damaged output shaft splines	Replace output shaft
	Transmission shafts out of alignment	Align transmission shafts
	Damaged sliding gear teeth	Replace sliding gear

TRANSMISSION PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Gears clash during shifting	Worn or damaged synchronizer rings and/or speed gear cone surface	Replace synchronizer rings and/or speed gears
	Improper clutch pedal free travel adjustment	Adjust free travel
	Dry, damaged, binding, or misaligned clutch linkage	Inspect, align, and lubricate clutch linkage
	Low or incorrect transmission lubricant	Fill with correct lubricant
	Worn or damaged synchronizer assembly	Replace synchronizer assembly
	Shift linkage needs repair or adjustment	Repair and/or adjust shift linkage
	Loose or misaligned clutch housing and/or transmission case	Align and tighten clutch housing and/or transmission case
	Worn or damaged gear shift mechanism	Repair or replace gear shift parts
	Excessive output shaft end play	Correct end play
	Dry, worn, damaged, or misaligned parts in the release bearing mechanism	Inspect, lubricate, or replace the release bearing, release fork, transmission input shaft bearing retainer, return springs, and pressure plate assembly return levers or diaphragm spring
	Idle speed too high	Reduce idle speed to specifications
	Worn needle or roller bearings	Replace bearings
	Worn or damaged input shaft bearings	Replace input shaft bearings
	Weak or broken detent springs	Replace detent springs
	Dry, worn, or loose pilot bushing/bearing	Replace bushing/bearing

TRANSMISSION PFRFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transmission sticks in a gear	Synchronizer ring caught on speed gear cone	Replace synchronizer rings and/or speed gears
	Shift linkage needs lubrication, repair, or adjustment	Lubricate, repair, or adjust shift linkage
	Interlock or detent plugs (or balls) binding	Service and/or replace binding parts
	Damaged internal shift linkage components	Inspect and repair shift linkage components
	Sliding gears tight or binding on output shaft	Repair or replace sliding gears or output shaft
	Low or incorrect transmission lubricant	Fill with correct lubricant
	Dry bearings	Replace bearings and lubricate correctly
	Damaged synchronizer teeth	Replace synchronizer
Transmission will not shift into a gear	Damaged or worn synchronizer assembly	Replace synchronizer assembly
	Damaged shift linkage	Repair or replace linkage
Transmission cannot be shifted out of a gear	Shift linkage damaged or installed incorrectly	Inspect and repair linkage; install correctly
	Worn or broken shift rail or shift fork	Replace worn or damaged parts
	Worn or damaged gear shift lever	Replace gear shift lever
No power through transmission	Broken gear or shaft	Replace broken part
	Gear teeth stripped	Replace gears
	Broken shift linkage	Inspect, repair, and adjust linkage
	Input shaft spline sheared off	Replace input shaft

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TRANSMISSION NOISE DIAGNOSIS CHART

Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
The noise gets louder during acceleration	Bad gear or bearing	Inspect and replace the faulty part
Clicking or knocking	Broken gear teeth	Replace bad gears
Growling	Bad bearing	Replace bearing
Transmission noisy in neutral	Worn or damaged part on countershaft assembly	Inspect and replace damaged parts
	Excessive countershaft end play	Correct end play
	Dry, worn, or damaged bearings	Replace bearings
	Loose or misaligned clutch housing and/or transmission case	Align and tighten clutch housing and/or transmission case
	Speed gears loose on output shaft	Replace speed gears and/or output shaft
	Low or incorrect transmission lubricant	Fill with correct lubricant
	Worn or damaged speed gears	Replace speed gears
Transmission noisy in gear	Dry, worn, or damaged bearings or bushings	Replace affected bearings or bushings
	Low or incorrect transmission lubricant	Fill with correct lubricant
	Worn or damaged speed gears	Replace speed gears
	Damaged or worn synchronizer assembly	Replace synchronizer assembly
	Excessive end play on input shaft, output shaft, or countershaft	Correct end play

TRANSMISSION NOISE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transmission noisy in gear (continued)	Worn speedometer gear	Replace speedometer gear
	Worn or damaged countershaft gears and/or bearings	Replace countershaft gears and/or bearings
	Worn or damaged input shaft gear	Replace input shaft
	Speed gears loose on output shaft	Replace speed gears and/or output shaft
	Loose or misaligned clutch housing and/or transmission case	Align and tighten clutch housing and/or transmission case
Transmission noisy in reverse only	Worn or damaged reverse idler gear, bearing or bushing, or shaft	Replace reverse idler gear shaft
	Worn or damaged reverse gear and/or bearings on output shaft	Replace reverse gear and/or bearings
	Shift linkage needs adjustment or repair	Adjust shift linkage

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TRANSMISSION LEAK DIAGNOSIS CHART

Causes that are more probable are listed first.

POSSIBLE CAUSES	CORRECTIVE ACTION
Transmission fluid level too high	Reduce fluid level to just below the fill hole
Plugged vent	Unclog vent
Damaged or improperly installed oil seals	Replace oil seals
Loose or damaged input shaft bearing retainer	Tighten and/or replace input shaft bearing retainer
Loose side cover	Tighten side cover
Loose drain plug	Tighten drain plug
Damaged or missing gaskets	Replace gaskets
Loose or missing bolts	Replace and tighten bolts, using thread-locking compound on threads
Stripped bolt threads	Repair bolt threads
Transmission case damaged	Replace transmission case
Worn or damaged shift lever seal	Replace shift lever seal
Countershaft loose in case	Replace transmission case
Loose or missing expansion plug	Replace expansion plug
Lubricant foaming excessively	Drain lubricant and replace

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HOW TO FIGURE TRANSMISSION GEAR RATIOS— THE TORQUE MULTIPLICATION FACTOR

When transmission gears must be replaced, the technician checks the part numbers of the old gears and orders the new parts by number. If you cannot locate the part number, the dealership or parts house can usually provide you with the correct part if you can tell them the type of transmission, the year and model of the vehicle, and which gear you need. However, sometimes an automotive technician may want to figure the gear ratios of the transmission gears.

REVIEW GEAR RATIOS

The gear ratio between two gears represents the number of turns made by the drive gear to complete one complete turn of the driven gear.

$$\text{No. of revolutions of the drive gear} : \text{No. of revolutions of the driven gear}$$

$$x.xx : 1$$

To find the gear ratio of two gears, divide number of teeth on the driven gear by the number of teeth on the drive gear:

$$\frac{\text{\# Teeth on driven gear}}{\text{\# Teeth on drive gear}} = \text{Gear ratio}$$

A ***transmission gear ratio*** tells you how many times the input shaft must turn to produce *one* turn of the output shaft. If the transmission gear ratio is 3.00:1, the input shaft turns three times every time the output shaft turns once.

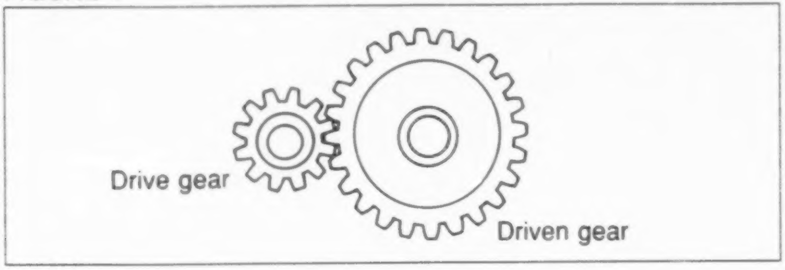
Figuring the gear ratio of transmission gears is complicated by the fact that *more than one pair of gears is involved in turning the output shaft*. When torque is increased by passing through several gears, the resulting ratio is called the ***torque multiplication factor***.

NOTE: If torque is *decreased* by passing through gears, the resulting ratio is called the ***speed multiplication factor***. The ratio of a transmission overdrive gear is a result of a speed multiplication factor.

HOW TO FIGURE TORQUE MULTIPLICATION FACTORS:

When you figure the gear ratio of a gear set involving two gears, you divide the number of teeth on the driven gear by the number of teeth on the drive gear: (Figure 1)

FIGURE 1



FORMULA:

$$\frac{\textbf{\# Teeth on driven gear}}{\textbf{\# Teeth on drive gear}}$$

EXAMPLE:

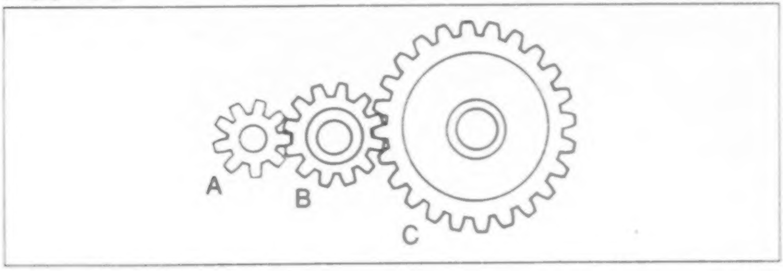
DRIVEN GEAR

$$\frac{\text{24 gear teeth}}{\text{12 gear teeth}} = \frac{24}{12} = 2.00:1$$

DRIVE GEAR

To figure the torque multiplication factor of a gear set involving three or more gears (Figure 2), you do exactly the same thing, but you figure the gear ratio of each *pair* of gears and then multiply the gear ratios of each pair. This method is used no matter how many gears are in the gear set.

FIGURE 2



1ST PAIR — 2ND PAIR

$$\underbrace{\frac{\textbf{\# Teeth on driven gear}}{\textbf{\# Teeth on drive gear}}}_{\text{1ST PAIR}} \times \underbrace{\frac{\textbf{\# Teeth on driven gear}}{\textbf{\# Teeth on drive gear}}}_{\text{2ND PAIR}} = \textbf{Torque Multiplication Factor (TMF)}$$

EXAMPLE:

If gear A drives gear B, and gear B drives gear C, the problem would look like this:

$$\frac{\#\text{ teeth on gear B}}{\#\text{ teeth on gear A}} \times \frac{\#\text{ teeth on gear C}}{\#\text{ teeth on gear B}} = \text{TMF}$$

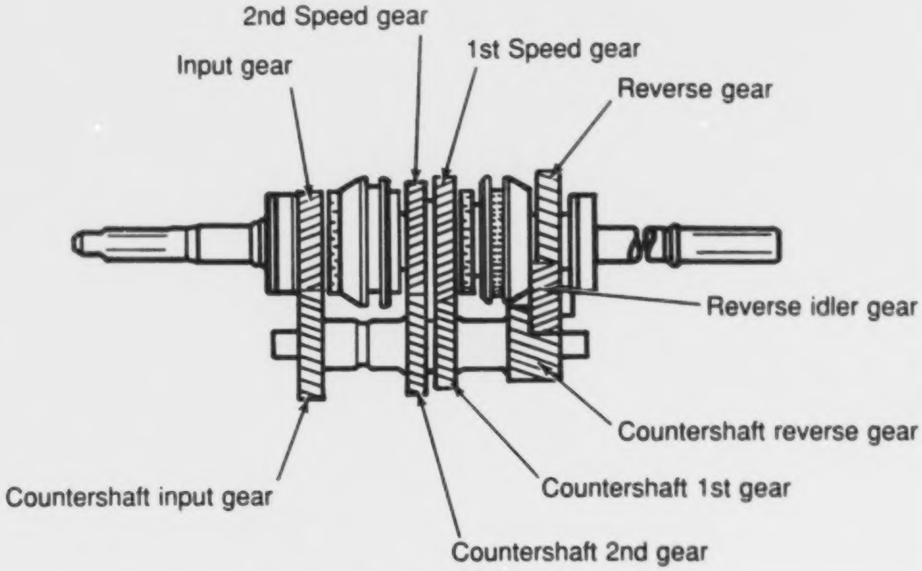
If A has 10 teeth, B has 16 teeth, and C has 25 teeth:

$$\frac{12}{9} \times \frac{24}{12} = \frac{288}{108} = 2.67$$

The torque multiplication factor of the set is 2.67:1

HOW TO FIGURE THE TORQUE MULTIPLICATION FACTOR OF TRANSMISSION GEARS:

FIGURE 3


2nd Speed gear
Input gear
1st Speed gear
Reverse gear
Reverse idler gear
Countershaft reverse gear
Countershaft 1st gear
Countershaft input gear
Countershaft 2nd gear

Forward Gears

Unless the transmission is shifted into a gear which has a 1.00:1 ratio (where the power flows directly into the input shaft and out the output shaft), the forward power flow in a transmission passes through:

(1) the **input gear**
(2) the **countershaft input gear**
(3) a **countershaft drive gear**, and
(4) an **output shaft speed gear**.

The formula for figuring the torque multiplication factor (TMF) of forward transmission gears is:

$$\frac{\textbf{Countershaft input gear}}{\textbf{Input gear}} \times \frac{\textbf{Output shaft speed gear}}{\textbf{Countershaft drive gear}} = \textbf{TMF}$$

NOTE: Notice that in both cases the drive gear is on the bottom and the driven gear is on the top.

EXAMPLES:

In a 3-speed transmission, the number of teeth on the input gear is 19, the countershaft input gear has 28, the 1st gear countershaft drive gear has 15, the 2nd gear countershaft drive gear has 21, the countershaft reverse gear has 14, the output shaft 1st speed gear has 29, the output shaft 2nd speed gear has 24, the output shaft reverse gear has 28, and the reverse idler gear has 14. Third gear is a direct gear.

What is the torque multiplication factor of 1st gear?

$$\frac{28}{19} \times \frac{29}{15} = \frac{812}{285} = \mathbf{2.85:1}$$

What is the torque multiplication factor of 2nd gear?

$$\frac{28}{19} \times \frac{24}{21} = \frac{672}{399} = \mathbf{1.68:1}$$

What is the torque multiplication factor of 3rd gear?

The torque multiplication factor of a direct gear is always **1:1**.

Reverse Gear

When the transmission is in reverse, the power flows through:

(1) the **input gear**,
(2) the **countershaft input gear**,
(3) the **countershaft reverse gear**,
(4) the **reverse idler gear**, and
(5) the **output shaft reverse gear**.

The formula for figuring the torque multiplication factor of a reverse transmission gear is:

$$\frac{\text{Countershaft input gear}}{\text{Input gear}} \times \frac{\text{Reverse idler gear}}{\text{Countershaft reverse gear}} \times \frac{\text{Output shaft reverse gear}}{\text{Reverse idler gear}} = \text{TMF}$$

NOTE: Notice that in all cases the drive gear is on the bottom and the driven gear is on the top.

EXAMPLE: What is the torque multiplication factor of reverse gear in the above example?

$$\frac{28}{19} \times \frac{14}{14} \times \frac{28}{14} = \frac{10976}{3724} = \mathbf{2.95:1}$$

Activity Sheet 1 contains practice problems for calculating transmission torque multiplication ratios.

OVERALL TORQUE MULTIPLICATION

The method you have just learned for figuring torque multiplication is useful *no matter how many gears the torque passes through.* To figure the torque multiplication of a transaxle, a transfer case, or an entire drivetrain:

(1) Identify the gear sets through which the torque passes,

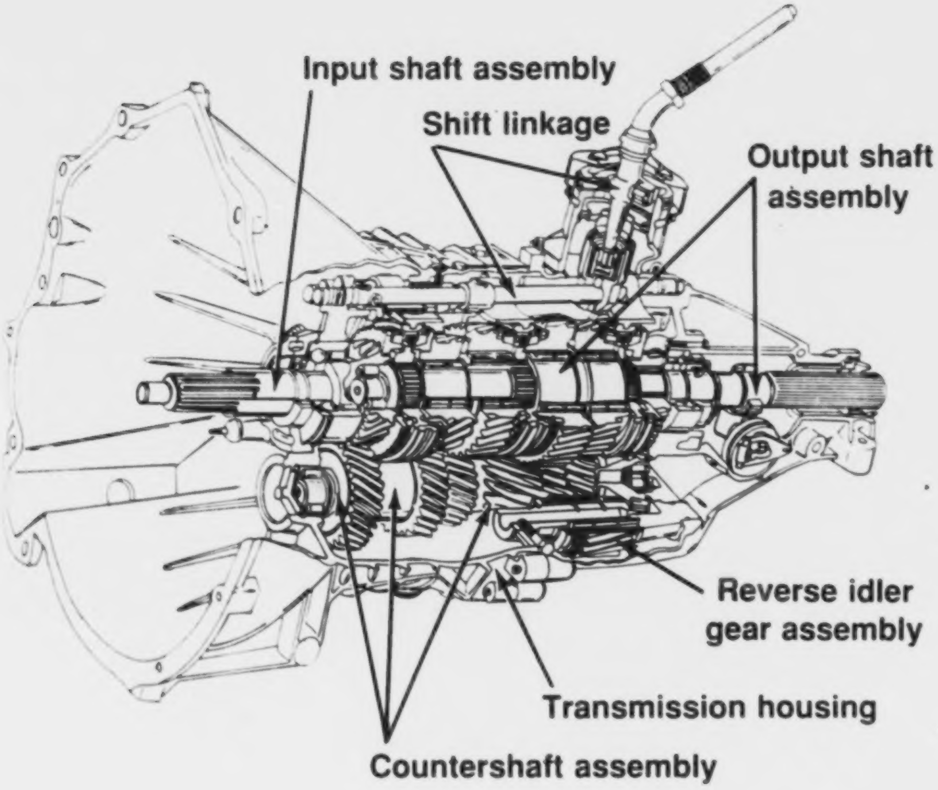
(2) Put the driven gear in each set on the top of a fraction and the drive gear on the bottom,

(3) Then multiply the gear sets by each other.

(4) Format the resulting decimal to two decimal places and express it as a ratio: X.XX:1.

$$\frac{B}{A} \times \frac{C}{B} \times \frac{D}{C} \times \frac{E}{D} \times \frac{F}{E} = \text{TMF}$$

Basic Parts of a Transmission


Input shaft assembly
Shift linkage
Output shaft assembly
Reverse idler gear assembly
Transmission housing
Countershaft assembly

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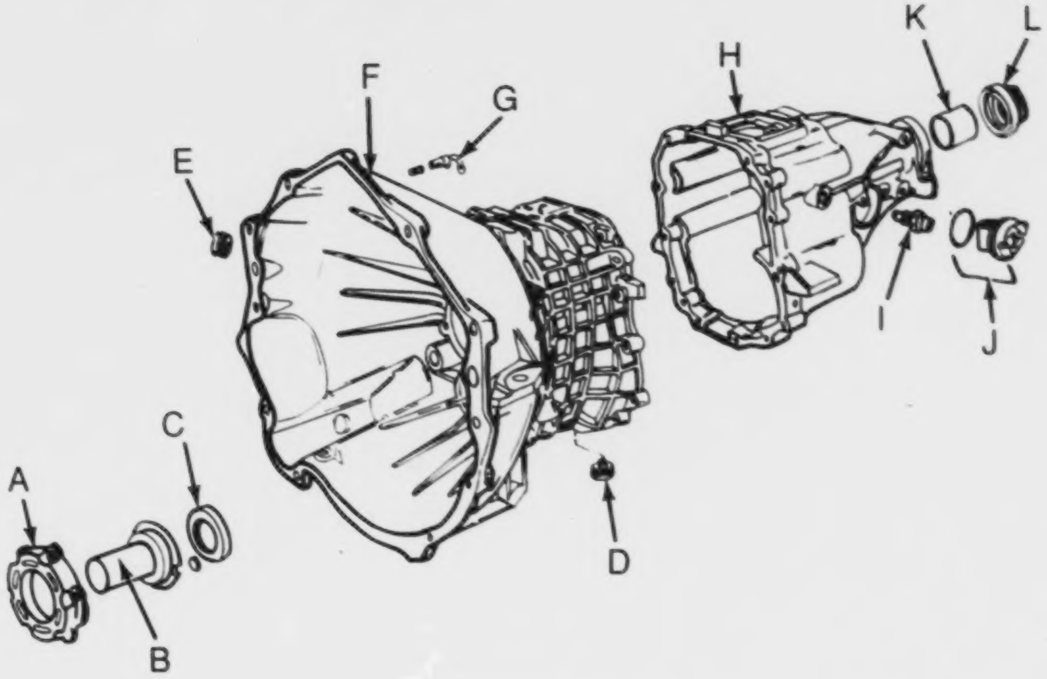
Transmission Housing



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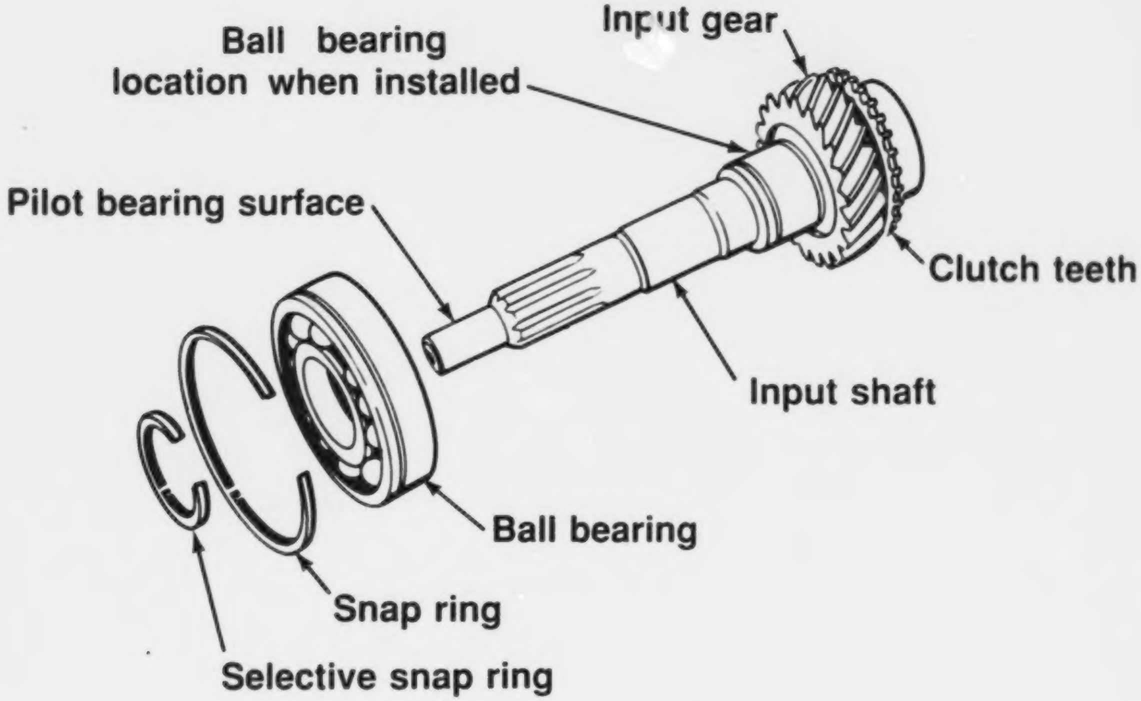
A	Input shaft bearing retainer
B	Retainer sleeve
C	Input shaft oil seal
D	Oil drain plug
E	Oil fill plug
F	Front transmission housing
G	Vent
H	Rear transmission housing
I	Back-up light switch
J	Speed sensor assembly
K	Rear bearing extension
L	Slip yoke oil seal

Input Shaft Assembly


Input gear
Ball bearing location when installed
Pilot bearing surface
Clutch teeth
Input shaft
Ball bearing
Snap ring
Selective snap ring

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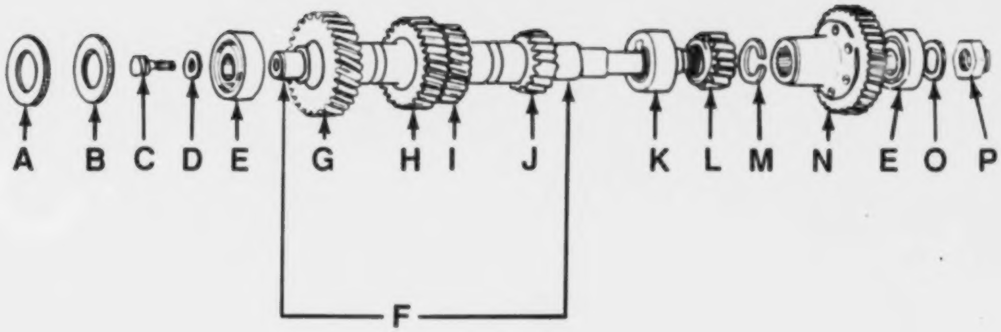
Countershaft Assembly



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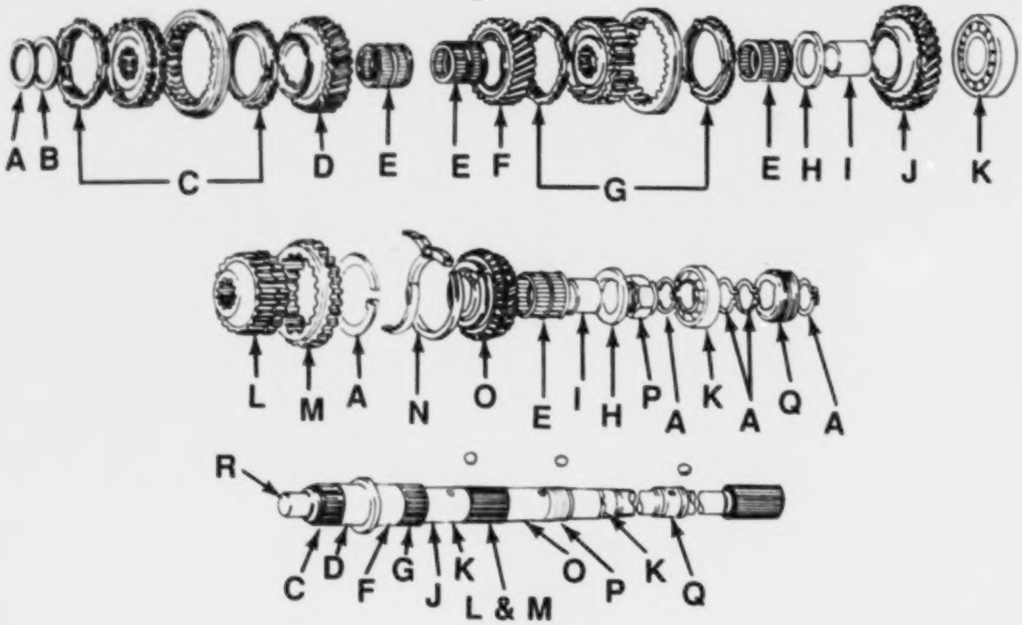
A	Shim
B	Thrust washer
C	Bolt with washer
D	Washer
E	Ball bearing
F	Cluster gear
G	Cluster input gear
H	Cluster gear 3rd gear
I	Cluster gear 2nd gear
J	Cluster gear 1st gear
K	Roller bearing
L	Countershaft reverse gear
M	Snap ring
N	Countershaft 5th gear
O	Shim
P	Nut

Output Shaft Assembly


A
B
C
D
E
E
F
G
E
H
I
J
K
L
M
A
N
O
E
I
H
P
A
K
A
Q
A
R
C
D
F
G
J
K
L & M
O
P
K
Q

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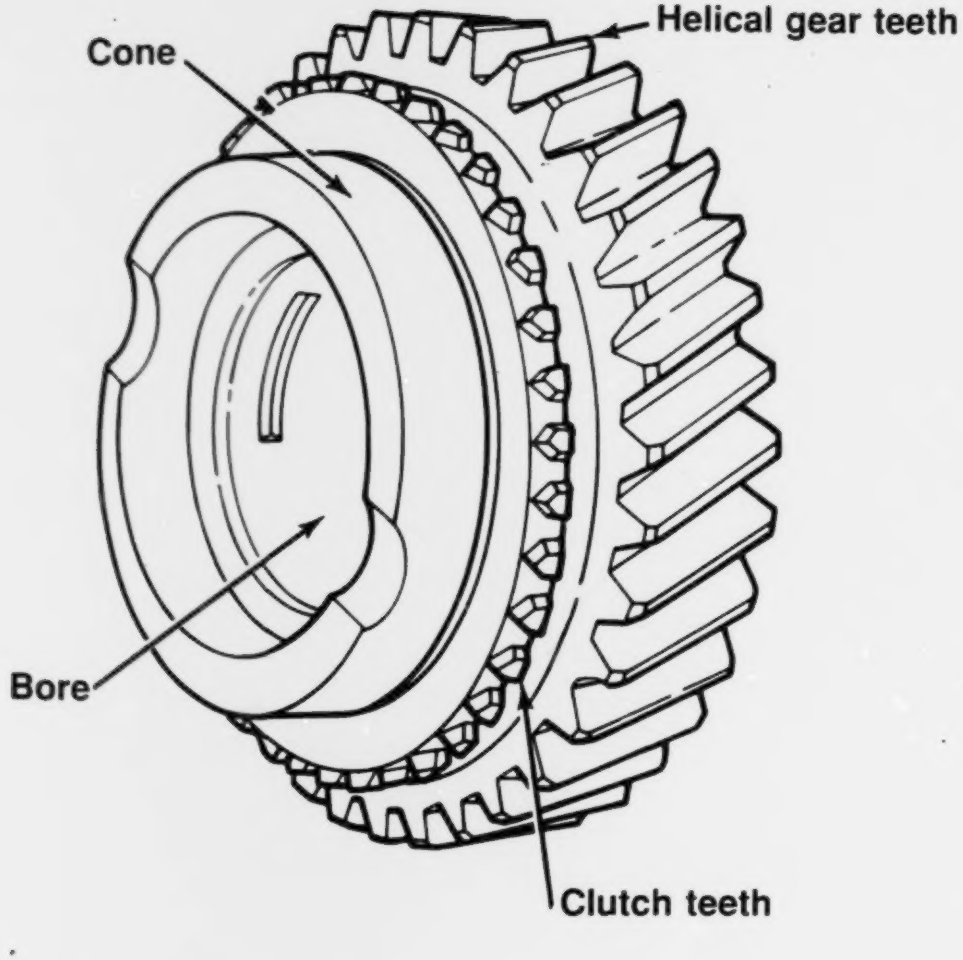
A	Snap ring
B	Washer
C	3rd & 5th gear synchronizer assembly
D	3rd gear
E	Caged needle bearings
F	2nd gear
G	1st & 2nd gear synchronizer assembly
H	Thrust washer
I	Bushing
J	1st gear
K	Ball bearing
L	Synchronizer hub
M	Sliding reverse gear
N	Synchronizer ring
O	5th gear
P	Output shaft nut
Q	Speedometer drive gear
R	Output shaft

Speed Gear


Helical gear teeth
Cone
Bore
Clutch teeth

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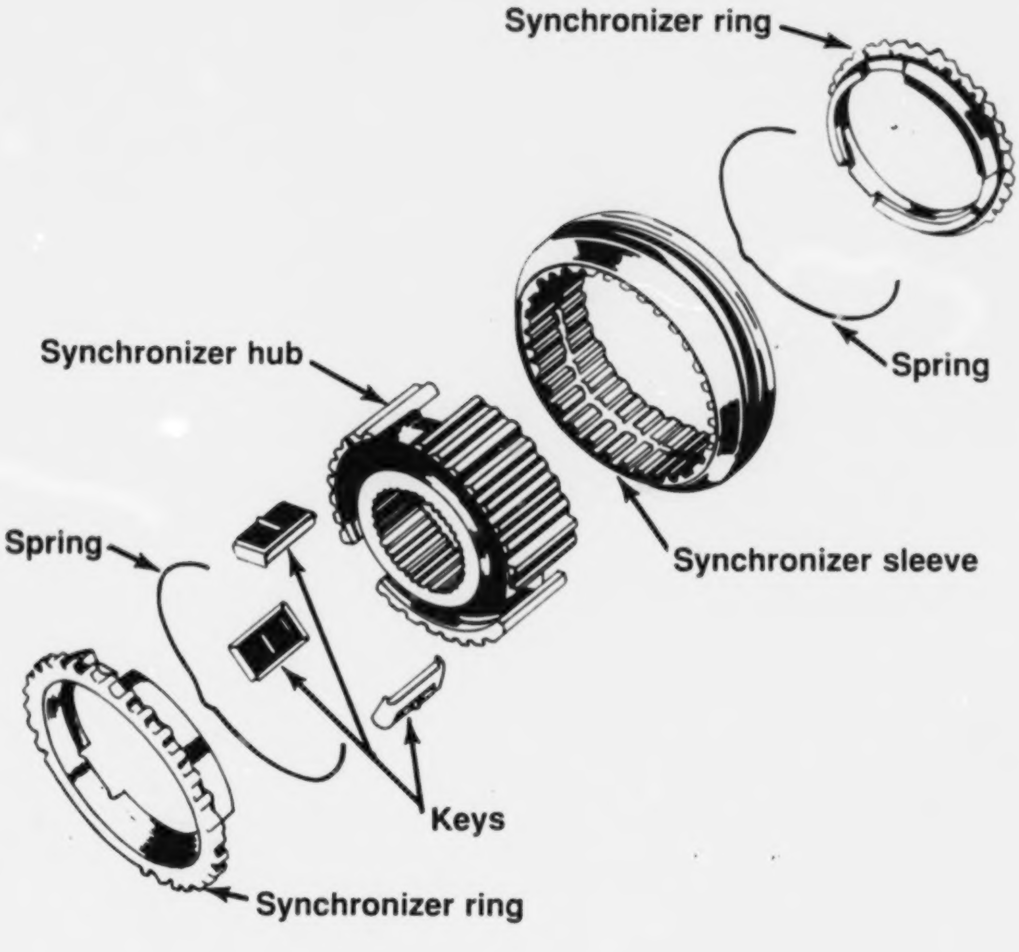
Key Type Synchronizer Assembly


Synchronizer ring
Spring
Synchronizer hub
Synchronizer sleeve
Spring
Keys
Synchronizer ring

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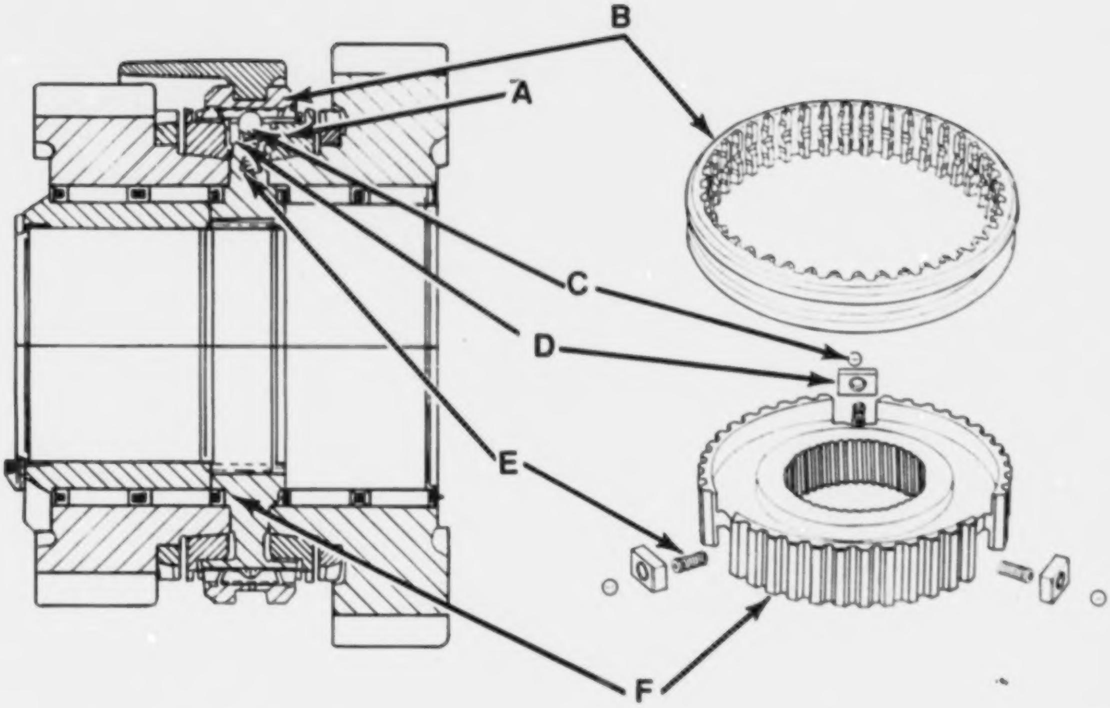
Ball Type Synchronizer Assembly



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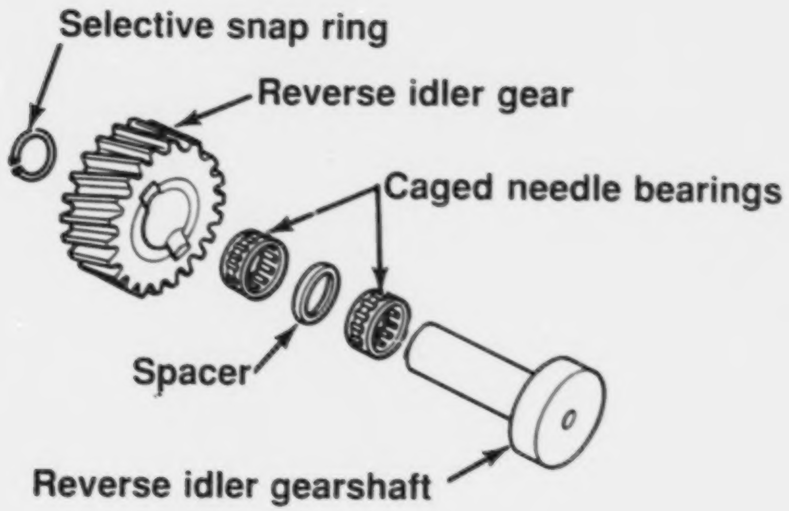
A Synchronizer ring
B Synchronizer sleeve
C Ball

D Key
E Spring
F Synchronizer hub

Reverse Idler Gear Assembly


Selective snap ring
Reverse idler gear
Caged needle bearings
Spacer
Reverse idler gearshaft

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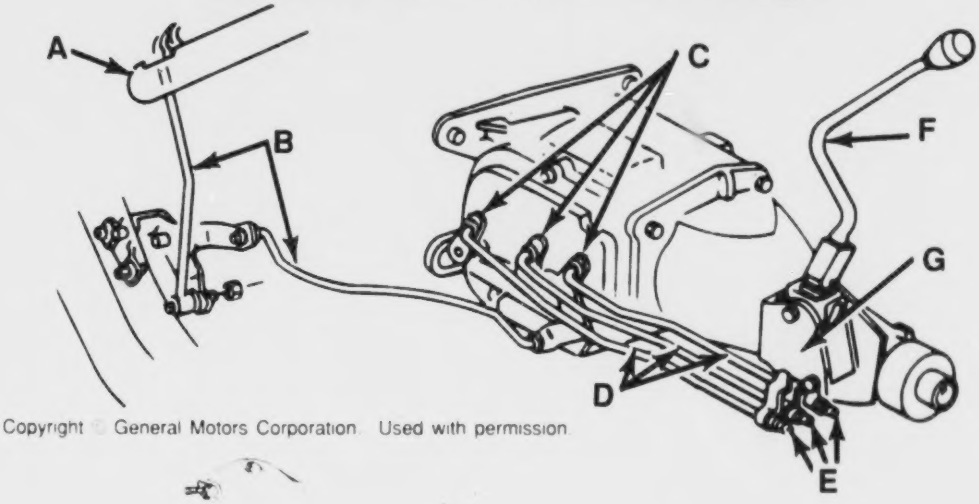
External Shift Linkage



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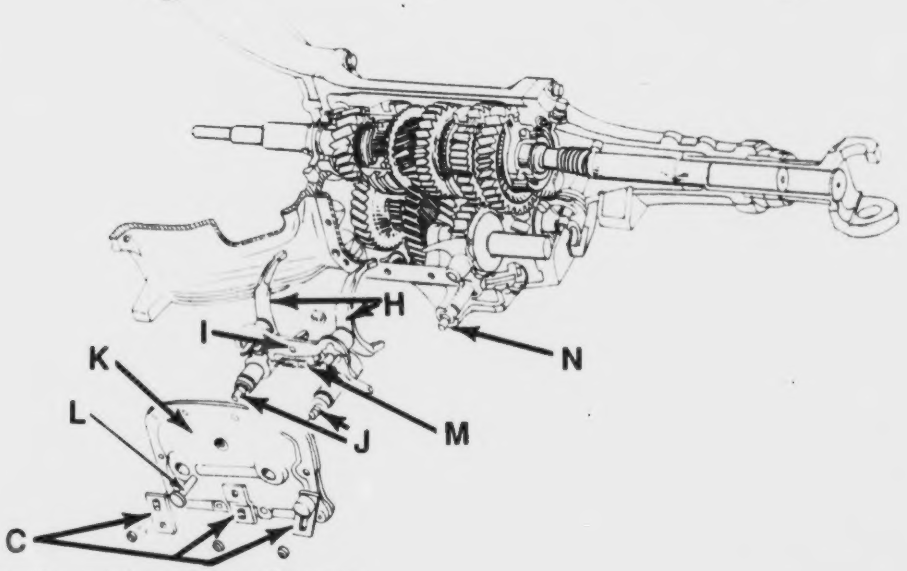
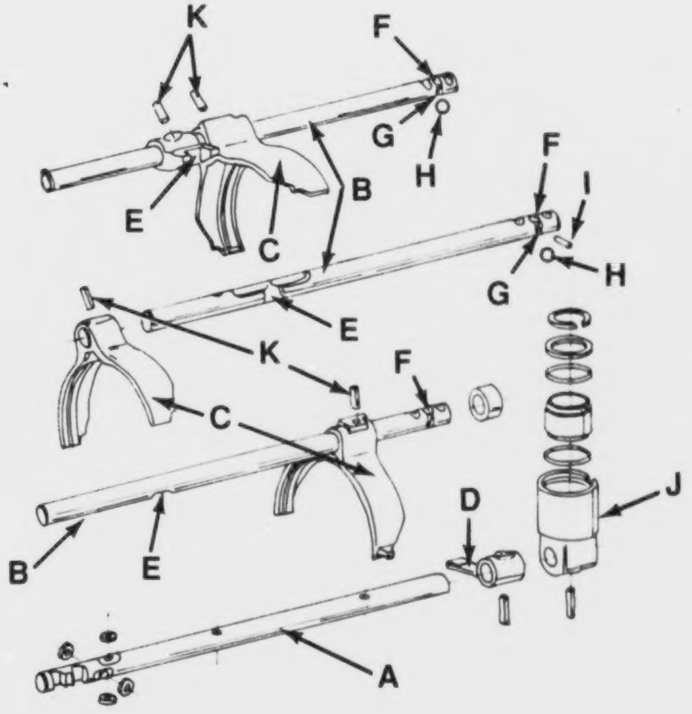


Used with permission of Chrysler Corporation.

A	Steering column	H	Shift forks
B	Transmission lock rod	I	Detent cams
C	Shifter arms	J	Shifter shafts
D	Shift linkage rods	K	Shift cover
E	Linkage rod levers	L	Detent cam shaft
F	Gear shift lever	M	Detent spring
G	Gear shift lever bracket	N	Shifter shaft for reverse

Internal Shift Linkage



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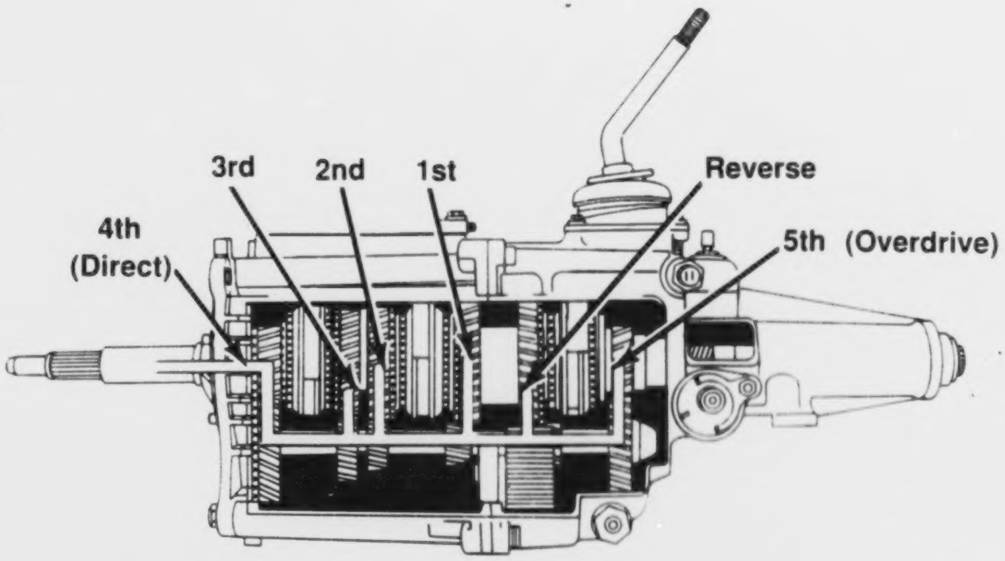
A	Shift shaft
B	Shift rail
C	Shift fork
D	Shift shaft finger
E	Notch contacted by shift shaft finger to move shift fork
F	Notch for shift detent ball
G	Notch for interlock balls
H	Interlock ball
I	Interlock pin
J	Gear shift lever tower
K	Drift pin

Neutral


3rd
2nd
1st
Reverse
4th
(Direct)
5th (Overdrive)

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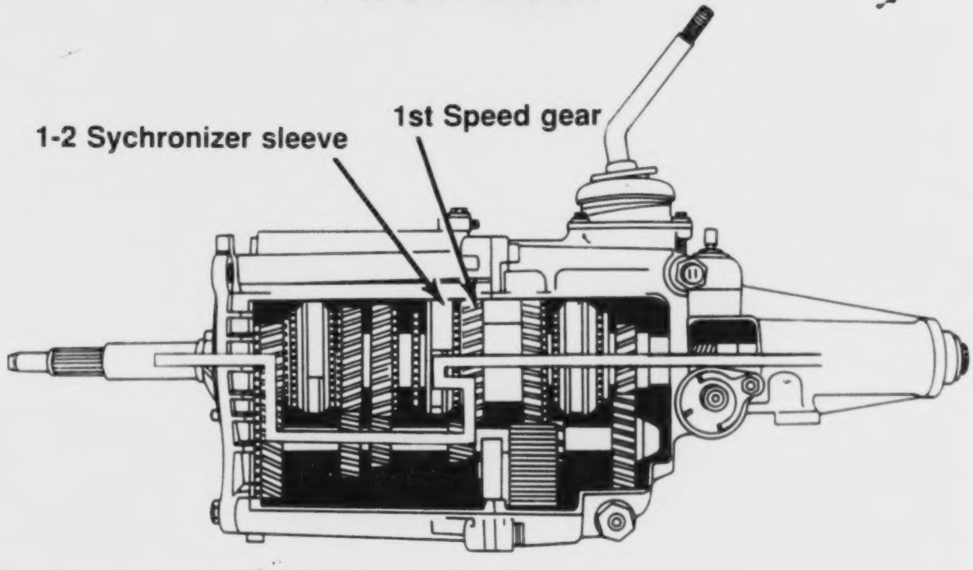
First Gear


1st Speed gear
1-2 Sychronizer sleeve

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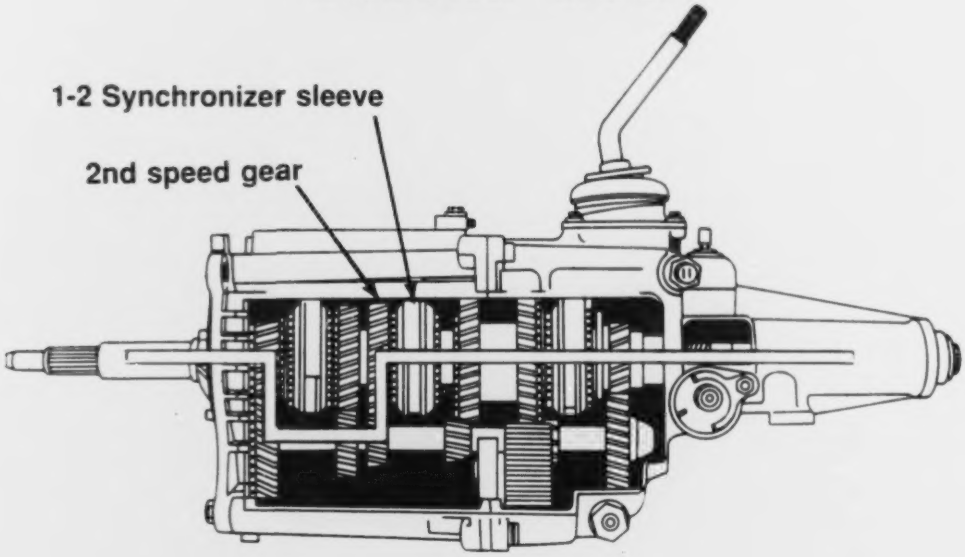
Second Gear


1-2 Synchronizer sleeve
2nd speed gear

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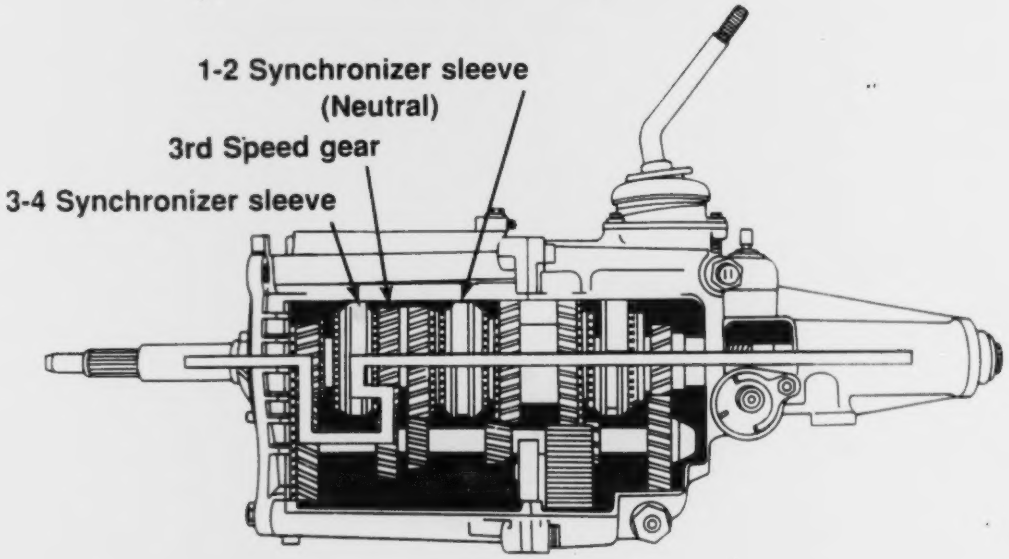
Third Gear


1-2 Synchronizer sleeve
(Neutral)
3rd Speed gear
3-4 Synchronizer sleeve

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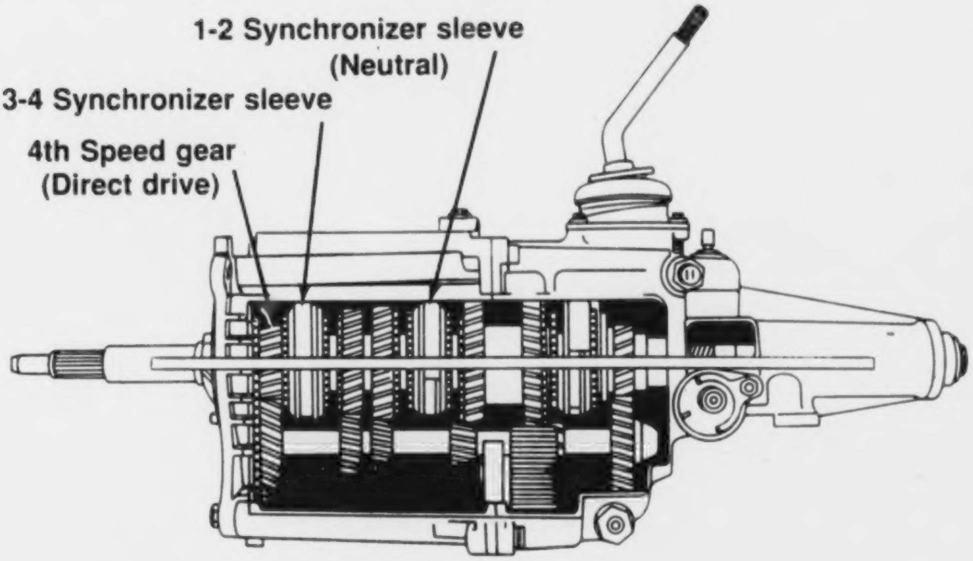
Fourth Gear


1-2 Synchronizer sleeve
(Neutral)
3-4 Synchronizer sleeve
4th Speed gear
(Direct drive)

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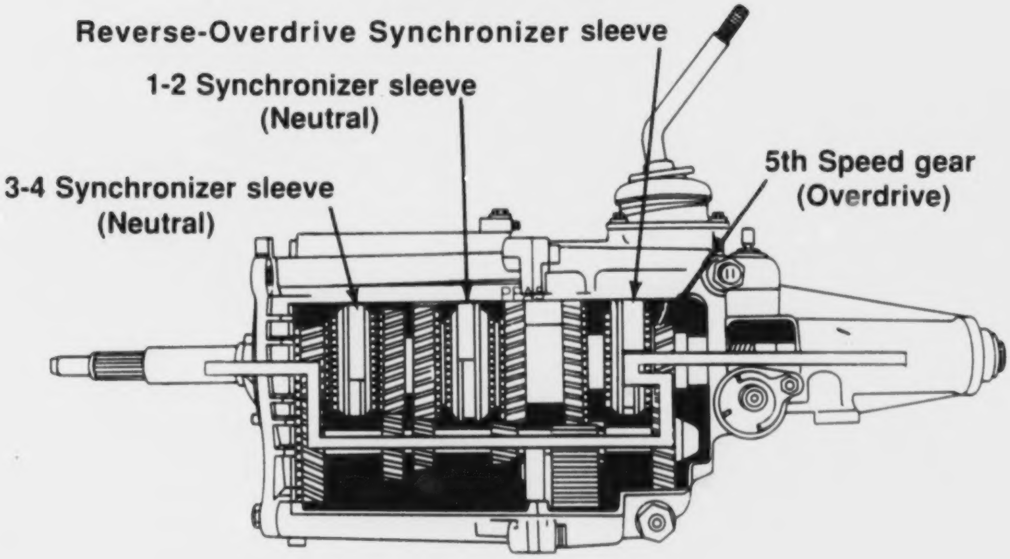
Fifth Gear


Reverse-Overdrive Synchronizer sleeve
1-2 Synchronizer sleeve
(Neutral)
5th Speed gear
(Overdrive)
3-4 Synchronizer sleeve
(Neutral)

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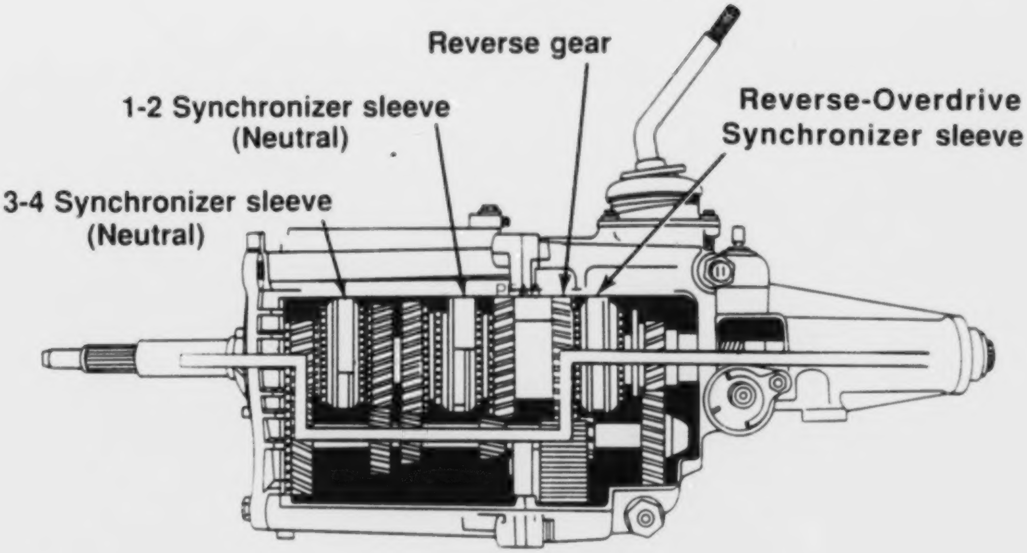
Reverse


Reverse gear
1-2 Synchronizer sleeve (Neutral)
Reverse-Overdrive Synchronizer sleeve
3-4 Synchronizer sleeve (Neutral)

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ACTIVITY SHEET 1

SERVICE MANUAL TRANSMISSIONS

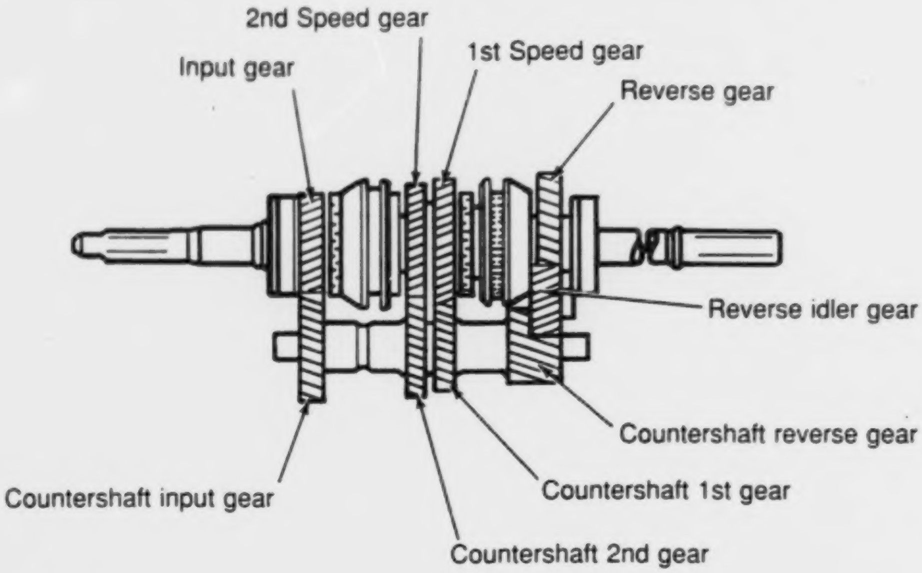
IV

NAME ______________________________ SCORE ________

FIGURING TRANSMISSION TORQUE MULTIPLICATION FACTORS

INTRODUCTION

FIGURE 1


2nd Speed gear
Input gear
1st Speed gear
Reverse gear
Reverse idler gear
Countershaft reverse gear
Countershaft input gear
Countershaft 1st gear
Countershaft 2nd gear

The formula for figuring the torque multiplication factor (TMF) of ***forward transmission gears*** is:

$$\frac{\text{Countershaft input gear}}{\text{Input gear}} \times \frac{\text{Output shaft speed gear}}{\text{Countershaft drive gear}} = \text{TMF}$$

The formula for figuring the torque multiplication factor for a ***reverse transmission gear*** is:

$$\frac{\text{Countershaft input gear}}{\text{Input gear}} \times \frac{\text{Reverse idler gear}}{\text{Countershaft reverse gear}} \times \frac{\text{Output shaft reverse gear}}{\text{Reverse idler gear}} = \text{TMF}$$

DIRECTIONS

Use Supplement 5, ***How to Figure Transmission Gear Ratios—The Torque Multiplication Factor*** to help you with the following ratio problems. Put a box around your answer.

NOTE: Remember to write your answer as a ratio and divide to two decimal places. For example: 2.32:1

USE THE GEAR TEETH NUMBERS FROM THE FOLLOWING 3-SPEED TRANSMISSION TO ANSWER QUESTIONS 1-4:

	No. of gear teeth
Input gear	15
Countershaft input gear	29
Countershaft 1st gear	18
Countershaft 2nd gear	24
Countershaft reverse gear	14
Reverse idler gear	18
Output shaft 1st gear	29
Output shaft 2nd gear	22
Output shaft reverse gear	29

3rd gear is a direct gear

1. What is the torque multiplication factor for 1st gear?

2. What is the torque multiplication factor for 2nd gear?

3. What is the torque multiplication factor for 3rd gear?

4. What is the torque multiplication factor for reverse?

USE THESE GEAR TEETH NUMBERS FROM A 4-SPEED TRUCK TRANSMISSION TO ANSWER QUESTIONS 5-9:

	No. of gear teeth
Input gear	17
Countershaft input gear	43
Countershaft 1st gear	14
Countershaft 2nd gear	25
Countershaft 3rd gear	35
Countershaft reverse gear	14
Reverse idler gear	21
Output shaft 1st gear	37
Output shaft 2nd gear	33
Output shaft 3rd gear	23
Output shaft reverse gear	37

5. What is the TMF of 1st gear?

6. What is the TMF of 2nd gear?

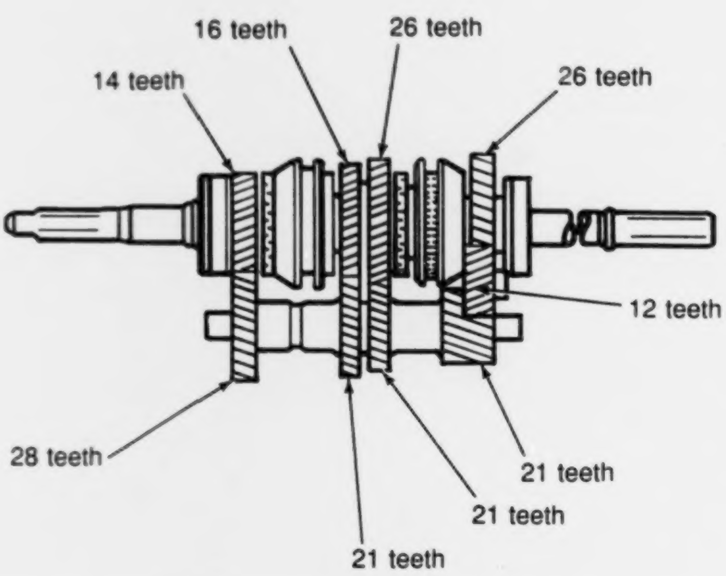
7. What is the TMF of 3rd gear?

8. What is the TMF of 4th gear?

9. What is the TMF of reverse?

USE THE FOLLOWING ILLUSTRATION TO ANSWER QUESTIONS 10-13:

FIGURE 2


16 teeth
26 teeth
14 teeth
26 teeth
12 teeth
28 teeth
21 teeth
21 teeth
21 teeth

10. What is the TMF of 1st gear?

11. What is the TMF of 2nd gear?

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12. What is the TMF of 3rd gear?

13. What is the TMF of reverse?

ACTIVITY SHEET 1

1. 3.11:1
2. 1.77:1
3. 1.00:1
4. 4.00:1
5. 6.68:1
6. 3.34:1
7. 1.66:1
8. 1.00:1
9. 6.68:1
10. 2.48:1
11. 1.52:1
12. 1.00:1
13. 2.48:1

ASSIGNMENT SHEET 1

SERVICE MANUAL TRANSMISSIONS

IV

NAME ______________________ SCORE ______

OBJECTIVE 14

Diagnose manual transmission noise and performance problems.

INTRODUCTION

Like clutch service, service on the transmission is time-consuming. Because of this, a good technician will always check to see if there are simple, easy-to-find solutions to problems that seem to be caused by the transmission before removing and disassembling it. Making an accurate diagnosis of the problem will eliminate costly mistakes.

Use Supplements 1, 2, 3, and 4, ***Transmission Troubleshooting Guide***, ***Transmission Performance Diagnosis Chart***, ***Transmission Noise Diagnosis Chart***, and ***Transmission Leak Diagnosis Chart***, to assist in diagnosing transmission problems.

DIRECTIONS

Study the Student Supplements mentioned just above, and then read each of the following questions carefully. Select the answer for each that is *most* correct. Write the correct letter in the blank.

______1. What is the purpose of a static shift test?

A. To test possible transmission performance problems
B. To help find problems with the transmission shift linkage
C. To help identify transmission noise problems
D. To eliminate the possibility of clutch problems

______2. A clicking or knocking clearly coming from the transmission is probably caused by:

A. A bad bushing
B. Excessive countershaft end play
C. Loose shift linkage
D. Broken gear teeth

______3. Which of the following is **not** something you are looking for when you first inspect the transmission during troubleshooting?

A. A worn output shaft
B. A transmission fluid leak
C. A damaged transmission case
D. A loose transmission mount

_______4. Which of the following could cause a transmission **not** to shift into a gear?

A. Damaged shift linkage assembly
B. Low or wrong transmission lubricant
C. Worn bearings
D. Excessive end play in a transmission shaft

_______5. The transmission shifts hard. Technician A says that the transmission shift linkage may need adjustment. Technician B says that the clutch pedal free travel may need adjustment. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_______6. Which of the following is a probable cause of transmission noise when the transmission is in neutral?

A. Loose speed gears
B. Worn or damaged synchronizer assembly
C. Shift linkage that needs adjustment or repair
D. Worn speedometer gear

_______7. The bolt threads in a transmission case are stripped. Technician A says that the case must be replaced. Technician B says only the bolts must be replaced. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_______8. Which of the following transmission problems could be clutch-related?

A. Gears clash when shifting
B. Transmission sticks in a gear
C. Transmission growls in first gear
D. All of the above

_______9. You find transmission fluid has leaked and is found all over the side of the transmission. Which of the following is a possible cause?

A. Loose side cover
B. Plugged vent
C. Transmission fluid level too high
D. All of the above

_____10. Which of the following could be caused by a misaligned clutch housing or transmission case?

A. Transmission sticks in a gear
B. No power through the transmission
C. Transmission jumps out of gear
D. Transmission noisy only in reverse

_____11. Which of the following is **not** a probable cause of the transmission jumping out of gear?

A. Low or wrong transmission lubricant
B. Loose shift linkage
C. Excessive crankshaft end play
D. Damaged shift fork

_____12. Transmission fluid is leaking from a crack in the transmission case. Technician A says that the case should be replaced. Technician B says that the case can be repaired. Who is correct?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____13. Which of the following transmission problems could be caused by a misaligned clutch housing?

A. Transmission jumps out of gear
B. Transmission cannot be shifted out of gear
C. Gears clash during shifting
D. Both A and C

_____14. The transmission is noisy only in reverse. Which of the following parts may be damaged?

A. Damaged countershaft gear
B. Damaged reverse speed gear
C. Damaged output shaft
D. None of the above

_____15. A transmission's gears are clashing when shifted, and you need to decide what to do first to solve the problem. Technician A suggests that you check and adjust the transmission shift linkage first. Technician B recommends that you overhaul the transmission. Whose advice should you follow?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

ASSIGNMENT SHEET 1

1. B
2. D
3. A
4. A
5. C
6. A
7. D
8. A
9. D
10. C
11. A
12. A
13. D
14. B
15. A

JOB SHEET 1

SERVICE MANUAL TRANSMISSIONS IV

OBJECTIVE 15A

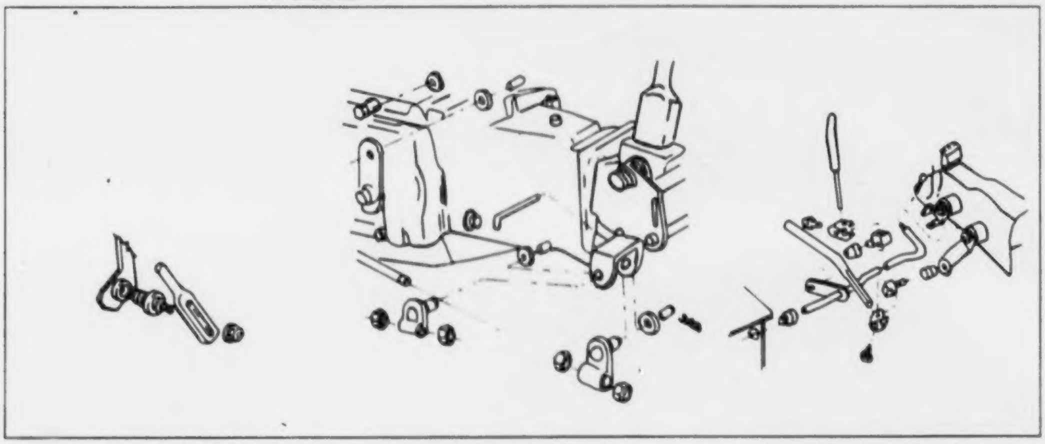
Inspect, replace, and adjust the external shift linkage parts located outside the transmission housing.

INTRODUCTION

External shift linkages may require adjustment of their shift linkage rods and other parts which are located outside the transmission housing. The linkage rods can become bent or damaged. The rubber or plastic bushings on the pivot points can become worn, loose, or fall off entirely. When any of these parts are damaged, worn, or missing, the shift linkage may not shift the transmission gears correctly, and major internal damage can result.

External shift linkages, like transmissions, vary greatly from vehicle to vehicle. Look at the following examples of how linkage rods are connected to the arms and levers. (Figure 1)

FIGURE 1



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Almost every model of vehicle has a transmission that is not like any other. Because of this, it is impossible to give any "standard" procedure for carrying out this job sheet—or any job sheet on a transmission. **YOU *MUST* USE THE SERVICE MANUAL FOR THE VEHICLE YOU ARE USING IN ORDER TO DO THE JOB SHEETS IN THIS UNIT**. The procedures given here are not exact, but they will give you an idea of the type of tasks that may be included.

EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle that has an external shift linkage
- Appropriate service manual
- Eye protection
- Hoist or jack stands
- Shop light
- Shop towels
- Approved cleaning solvent
- Combination wrenches
- Screwdriver
- White chassis grease for metal and nylon bushings
- Silicone-based grease for rubber bushings

> **CAUTION**
> **Always** check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect and replace the external shift linkage parts located outside the transmission housing

1. Set the vehicle's gear shift lever in neutral.
2. Raise the vehicle on a hoist or jack stands and support it safely.

   NOTE: Some external linkages, particularly column-mounted linkages, can be reached under the hood.

3. Use a shop light to locate the shift linkage rods and clean them off with a shop towel and approved cleaning solvent.
4. Inspect linkage components using the service manual to check for missing components.
5. Wiggle the linkage rods gently—they should not be loose.
6. Move the shifter arms on the transmission back and forth—if they do not move easily, the parts of the linkage inside the transmission housing could be damaged.
7. Inspect the linkage rods and linkage components for damage and wear.

   NOTE: Many linkage rods are normally bent. Refer to the vehicle service manual for the *correct* shape.

8. Replace any parts which are damaged, worn, or missing; do not attempt to adjust the linkage before replacements and repairs are made.

PROCEDURE

Adjust the external shift linkage parts located outside the transmission housing

1. Loosen the linkage rod adjustment screws, locknuts, or other devices which hold the linkage rods.

2. Set the shifter arms on the side of the transmission in neutral.

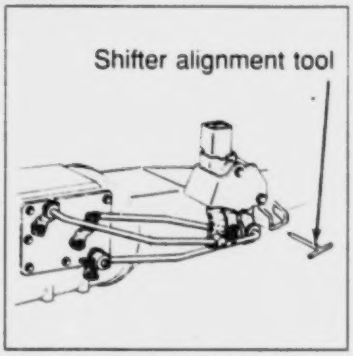
   NOTE: Shifter arms can be moved into three positions. Neutral is the position in the middle.

3. Put a shifter adjustment pin through both linkage rod levers and the gear shift lever bracket. (Figure 2)

   NOTE: This pin will hold the linkage rod levers in neutral.

4. Tighten the linkage rod adjustment screws/locknuts holding the linkage rod securely the correct distance between the shifter arm and the linkage rod levers.

FIGURE 2



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   NOTE: Check the service manual to see if any of the parts used to hold the linkage rods in place must be routinely replaced before making this adjustment.

5. Remove the shifter adjustment pin.

6. Check the transmission lock rod linkage for looseness and adjust as necessary.

   NOTE: The key should turn the ignition switch easily into and out of the lock position.

7. Lubricate the linkage pivot points and bushings with the appropriate lubricant.

8. Lower the vehicle.

9. Move the gear shift lever through all gears.

10. Road test the vehicle to make sure the linkage is working properly.

11. If the gear shift lever does not shift smoothly through all gears, recheck the linkage adjustment before considering the need for a transmission overhaul.

12. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

OBJECTIVE 15B

Inspect and replace transmission mounts.

INTRODUCTION

The transmission in a front-engine, rear-wheel drive vehicle is mounted directly behind the engine and the clutch. A steel support, called a ***crossmember***, is bolted to the vehicle's chassis and supports the weight of the transmission. Although there are several designs used for the transmission mount, they are all bolted across the chassis and commonly use some type of central support for the transmission. (Figures 1 and 2) The transmission mount in Figure 2 uses rubber blocks between the chassis and the crossmember to reduce vibration.

FIGURE 1

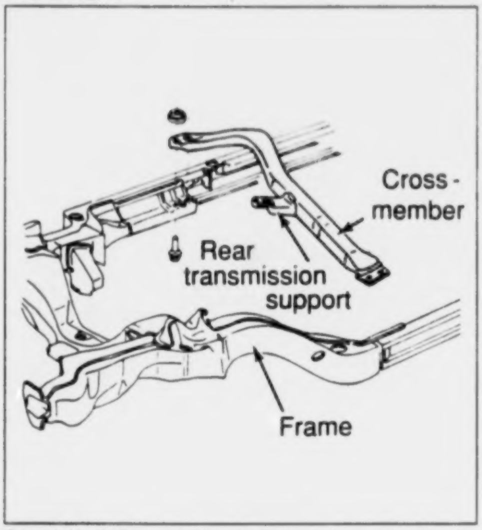

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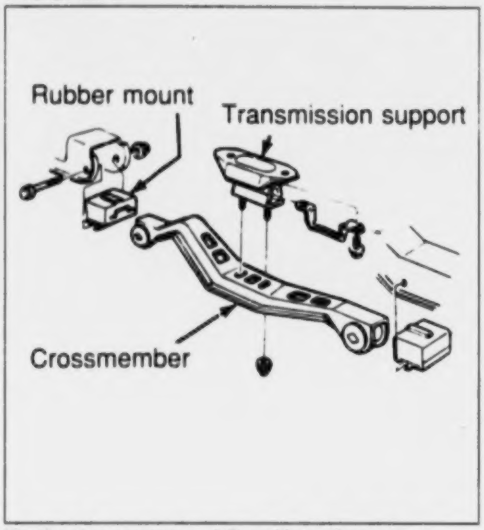
FIGURE 2



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EQUIPMENT AND MATERIALS

- Front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Job Sheet 4, Unit 3, ***Remove the Transmission and Clutch Housing***
- Eye protection
- Hoist and jack stands
- Shop light
- Shop towels
- Approved cleaning solvent

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be raised and supported safely.

PROCEDURE

Inspect and replace transmission mounts

1. Examine the transmission mount while the transmission is still in the vehicle.
2. Inspect the mount and the chassis where it is attached for any loose parts or obvious damage.
3. Check the area around the transmission and the transmission mount to make sure no parts are rubbing against the mount.
4. Use Job Sheet 4, Unit 3, to remove the transmission.
5. Remove the transmission mount from the chassis.
6. Use shop towels and an approved cleaning solvent to clean the transmission mount.
7. Recheck the mount for bends, cracks, or other signs of damage or wear.
8. Use the vehicle's service manual to check the mount for any missing parts.
9. If rubber mounts are used to mount the crossmember, examine them.
10. If the rubber is damaged, worn, hard, split, or spongy, replace the rubber mounts.
11. Replace any missing, worn, or damaged parts.
12. Replace the transmission mount.
13. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 3

SERVICE MANUAL TRANSMISSIONS

OBJECTIVE 15C **Disassemble a transmission.**

INTRODUCTION

Taking a transmission apart for overhaul is a very complicated and time-consuming job. The transmission should be disassembled only when the need for an overhaul is clearly indicated by diagnostic tests.

Because there are so many different makes of transmissions, the procedures for disassembling these transmissions are also different. You must refer to the vehicle's service manual for the correct method for the transmission being disassembled. **It is critical that each transmission be disassembled in the order recommended by the vehicle service manual.** Attention to every detail is extremely important. The following guidelines are useful for most transmissions:

Guidelines

- Use the transmission identification tag or number to help you identify the type of transmission installed in the vehicle. This information will also help you order replacement parts.
- Before you begin, steam clean the outside of the transmission housing or clean it with a wire brush, shop towels, and an approved cleaning solvent.
- Shift the transmission into neutral before starting disassembly.
- Keep in mind why the transmission is being disassembled as you examine the various components.
- Remember that an aluminum transmission housing is softer than the steel used for tools or for transmission components. Be careful not to damage the housing during disassembly.
- Remove and discard old gasket material. New ones will be used when the transmission is reassembled. Be sure not to scratch the transmission housing when removing the gasket material—leaks can result.
- As you separate the major components, handle them carefully, laying them aside in order on a clean shop towel where they cannot fall or become damaged.

- Inspect the transmission housing and each component for signs of wear or damage.

- Keep the parts of each assembly together in a plastic bag after they have been cleaned. Use masking tape to label any parts as necessary.

- Tag bolts as to location of removal and keep them together in a plastic bag.

EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

The transmission lubricant should be drained and the transmission should be removed from the vehicle. (Job Sheet 4, Unit 3)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

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JOB
SHEET 4

SERVICE MANUAL
TRANSMISSIONS

IV

OBJECTIVE 15D

Remove, inspect, and replace external shift assembly components located inside the transmission housing.

INTRODUCTION

The linkage of an external shift assembly is located outside the transmission housing. These linkage rods, pivots, and other parts are inspected and replaced during a linkage adjustment. (See Job Sheet 1.) However, some parts of an external shift assembly are located *inside* the transmission housing and during a transmission overhaul, these parts should be removed, inspected, and replaced.

Like other transmission components, external shift assemblies are manufactured in such a wide variety that the vehicle's service manual must be consulted for the correct procedure for the vehicle you are using. The following guidelines will give you some help with this procedure:

Guidelines

- Most manufacturers recommend that the shifter arms be set in neutral before beginning removal.
- Check the side cover at the following points for leaks:
    - Side cover gasket
    - Side cover bolts
    - Shifter shaft seals
- Clean all parts with a bristle brush and an approved cleaning solvent and blow dry with compressed air before inspection.
- Inspect the shift forks to make sure they are not bent, cracked, broken, or worn.
- Inspect the other parts of the shift assembly for wear or damage.
- Set the synchronizers on the output shaft in neutral before you replace the external shift linkage assembly.
- Make sure the shift forks are in the grooves of the synchronizers sleeves when you begin reinstallation.
- Use needle-nose pliers to help you replace the interlock spring.
- Always replace the rubber o-rings or lip seals on the shifter shafts when overhauling the shift mechanism.

- Any gaskets that are used with the side cover must be replaced when the assembly is reinstalled.

- Using too much sealer when replacing the side cover can result in a leak.

- After replacing the side cover, move each shift arm into each gear position to make sure the shift assembly is operating correctly.

EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle that has an external shift linkage
- Appropriate service manual
- Other equipment and material as required by procedure

The transmission should be removed from the vehicle. (Job Sheet 4, Unit 3)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 5

SERVICE MANUAL TRANSMISSIONS

IV

OBJECTIVE 15E

Remove, inspect, and replace internal shift assembly components.

INTRODUCTION

All of the parts of an internal shift assembly are located inside the transmission housing. During an overhaul, these parts are removed, inspected, and replaced. The parts and design of this assembly varies widely from transmission to transmission. The vehicle's service manual will guide you in the needed procedures.

Guidelines

- Usually the gear shift lever can be removed by removing the retaining bolts and lifting straight up on the lever.
- Use a magnet to remove the shift rail detent plug, spring, and plunger from the transmission housing.
- Mark the shift rails so they can be replaced in the same positions upon reassembly.
- Use a hammer and drift to remove the drift pins which hold the shift forks to the shift rails.
- Keep each shift fork with its corresponding shift rail. Often shift forks are not the same size.
- Clean all parts with a bristle brush and an approved cleaning solvent and blow dry with compressed air before inspection.
- Worn parts or worn or weak detent springs can cause the transmission to slip out of gear.
- Check the shift rails to make sure they are not bent, cracked, or broken.
- Put the rails into their bores and check their wear and the wear of any bushings by trying to move them back and forth. If they are loose, they should be replaced.
- Inspect the tips of the shift forks and the tip of the shift shaft finger for wear.
- Examine the interlock balls for signs of pitting or wear. Interlock balls or plugs are usually interchangeable.
- Slip the shift forks on their corresponding rails and move them back and forth. They should slide easily but without much play or wobble.

- All drift pins, detent plugs, and expansion plugs used in the internal shift assembly should be routinely replaced when the transmission is overhauled.

- To install a new expansion plug in the recess in a shift rail hole, hit the center of the plug with the round end of a ball peen hammer and the plug will expand to fit the hole. The center of the hole should be flush with or slightly below the housing surface.

- Shift the transmission through all gear ranges before replacing the transmission in the vehicle.

EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle which has an internal shift linkage
- Appropriate service manual
- Other equipment and material as required by procedure

The transmission should be removed from the vehicle. (Job Sheet 4, Unit 3)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15F

Remove, inspect, and replace input shaft assembly components.

INTRODUCTION

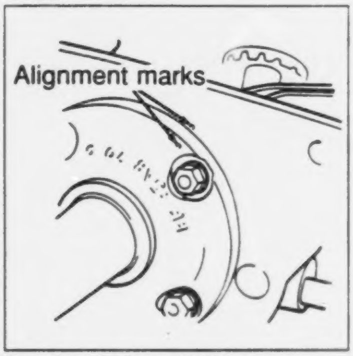
All input shafts are not put together and installed in the transmission housing in the same way. The parts of an input shaft are simple compared to other transmission components, but their proper condition and installation are critical to the operation of the entire transmission.

Because of the many different types of input shafts, you must use the vehicle's service manual to perform this job sheet correctly. The following guidelines will help you with most vehicles.

Guidelines

- Put matchmarks on the bearing retainer and the transmission housing so that they can be reassembled in their original positions. (Figure 1)
- The bearing retainer can usually be removed by bumping the end of it with the palm of your hand.
- As you disassemble the input shaft, put the parts in order on the workbench for easier reassembly.

FIGURE 1



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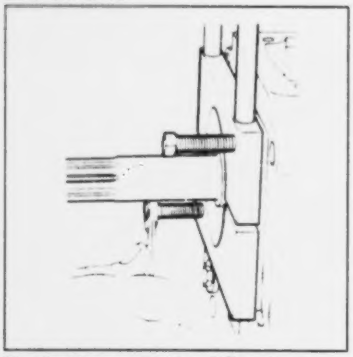
- Use snap ring pliers to remove snap rings.

◆ WARNING ◆

Overstretching snap rings can cause them to spring out unexpectedly, causing personal injury.

- Sometimes the bearing on the input shaft can be removed by just pulling it out of the housing. If this doesn't work, the best method of removal is to tap first on one side of the shaft and then on the other with a soft hammer. Do not try to drive the shaft out from the inside with a punch— the gear teeth may be damaged. In some housings the shaft must be removed from the housing with a puller. (Figure 2)

FIGURE 2



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- Use an arbor press and Supplement 7, Unit 2, "Removing and Replacing Pressed-On Bearings," to remove a pressed-on bearing from the input shaft.
- When removing bearings from shafts, be sure to note whether the snap ring groove is facing toward or away from the transmission. This will be important during bearing replacement.
- Use Supplement 5, Unit 2, "Cleaning, Inspecting, and Lubricating Antifriction Bearings," to inspect and clean the input shaft bearing. A worn or damaged bearing should be replaced promptly or expensive damage can result.
- Tip the transmission housing down at the front when you remove the input shaft. This will keep the needle bearings in the input shaft gear from falling into the transmission as it is removed.
- Keep the needle bearings together in a plastic bag so they won't be confused with bearings from other assemblies. Needle and roller bearings often appear to be the same size but are not.
- Seals can be removed with a screwdriver or puller. New seals will be installed on reassembly.
- Clean all parts with a bristle brush and an approved cleaning solvent and blow dry with compressed air before inspection.

- Inspect the area on the transmission housing where the input shaft bearing and bearing retainer are installed. Remove any gasket material. Smooth burrs with crocus cloth or a fine file.

- Inspect the front bearing retainer for cracks, burrs, or damage on the surface that mates with the transmission housing. The bearing retainer snout should be smooth.

- If the part of the shaft where the oil seal is installed is pitted, rusted, or scratched, it is best to replace the input shaft, or the seal will probably leak.

- Inspect the input shaft. The end of the shaft that rides in the pilot bearing/bushing should be smooth and not worn. Check the shaft splines for damage or wear that could keep the clutch disc from sliding evenly and smoothly.

- Make sure the lubrication hole in the input shaft is clean and open. If it is clogged, blow through it or use a wire to open the passage.

- Check small parts such as shims and washers against specifications. If they are damaged or worn, replace them. Worn parts can allow incorrect input shaft end play, resulting in overloaded and damaged bearings.

- The needle or roller bearings and the bore inside the input gear where they are installed should be free from damage or wear.

- Use a magnifying glass to examine the input shaft gear teeth for damage or wear. Replace the gear if it is worn or even slightly damaged. Damaged teeth are dangerous in a transmission. Broken parts or metal particles can be carried by the lubricant between meshing gears and cause more damage. Broken gear teeth also reduce the torque-carrying capacity of the gears, increasing the stress (and the possibility of further damage) on the remaining teeth.

- Check the tapered surface on the input shaft gear—it should be smooth and undamaged.

- If the input shaft gear is replaced because of damage, the corresponding countershaft gear must also be replaced.

- If any gear is damaged, make a special check of other gears in the transmission. There is an increased chance that other gears are also damaged.

- Check any replacement parts against the old parts and make sure they are alike. Compare the number of gear teeth on new gears to those they are replacing.

- After inspection, lightly lubricate all parts with the correct transmission lubricant before beginning reinstallation. Do not use too much lubricant. Too much oil will cause oil to get on the clutch disc, causing it to slip.

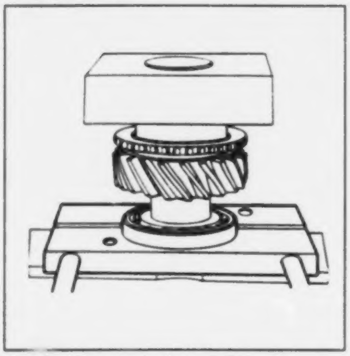
- Coat the input shaft gear bore with petroleum jelly to hold the needle bearings in place during reassembly. Using chassis grease or other heavy grease will clog the lubricant holes, keeping lubricant from circulating during operation.

- Routinely replace all snap rings, oil seals, and gasket material before reassembly.

- If indicated, use an arbor press to replace the bearing on the input shaft. (Figure 3)

- When bearings are installed directly into the housing, coat the bearing-to-housing surface with a sealant before installation. Use a special driver to drive the bearing into the housing.

FIGURE 3



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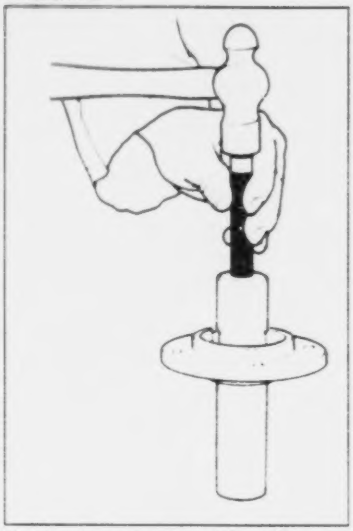
- When replacing the input shaft in the transmission housing, make sure the bearing retainer is installed flush with the housing.

- Use a special driver to install a new input shaft seal before reinstalling the input shaft. (Figure 4)
- Coat the threads of the bearing retainer bolts with thread-locking compound before reinstalling them.

FIGURE 4



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EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15G **Remove, inspect and replace output shaft assembly components.**

INTRODUCTION

The design of an output shaft depends both on the number of gears in the transmission and the general transmission design. An output shaft has many different parts that must be assembled *exactly* in the order the manufacturer specifies. Use the vehicle's service manual to guide you in the correct methods for the transmission you are using. The following guidelines will help you with some of the tasks:

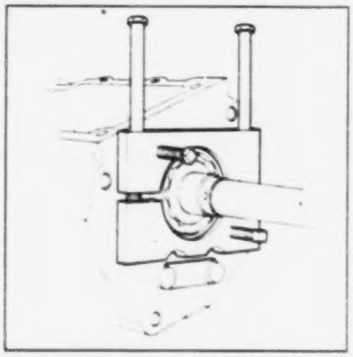
NOTE: Further guidelines for synchronizer assemblies are found in the next job sheet.

Guidelines

- As you disassemble the input shaft, put the parts in order on the workbench for easier reassembly.
- Before removing the output shaft, the rear bearing will have to be removed from the housing.

  NOTE: Often a bearing puller is used. (Figure 1)
- When removing bearings from shafts, be sure to note whether the snap ring groove is facing toward or away from the transmission. This will be important during bearing replacement.

FIGURE 1



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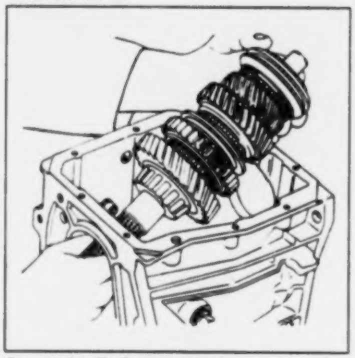
- Use Supplement 5, Unit 2, "Cleaning, Inspecting, and Lubricating Antifriction Bearings," to inspect and clean the output shaft bearing. A worn or damaged bearing should be replaced promptly or expensive damage can result.

- The output shaft is usually removed from the housing before disassembling its individual parts. (Figure 2)
- Be sure to save the small balls that are sometimes found between the part and the shaft and fall out when the part is removed; they help hold the part in place and are needed when the part is replaced.

FIGURE 2



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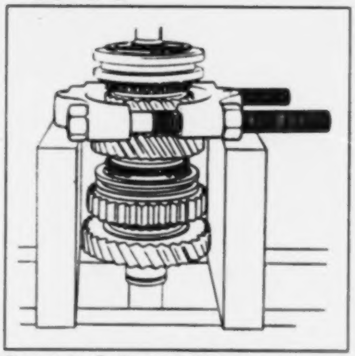
- Sometimes an arbor press is needed to remove and replace synchronizer hubs or speed gears from the output shaft. (Figure 3) Occasionally these parts must be heated before being pressed on the shaft.
- Keep the needle bearings together in a plastic bag so they won't be confused with bearings from other assemblies. Needle and roller bearings often appear to be the same size, but are not.

FIGURE 3



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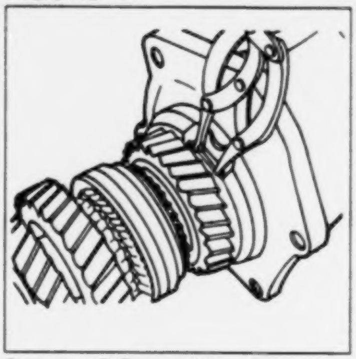
- Keep caged bearings with their own bushings and tag them according to their location on the shaft.
- Check the needle bearings and races for wear and damage. If any bearing must be replaced, replace all the bearings at that location. If either a caged bearing or its bushing needs replacement, replace both parts.

- Use snap ring pliers to remove snap rings. (Figure 4)

FIGURE 4



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◆ WARNING ◆

Overstretching snap rings can cause them to spring out unexpectedly, causing personal injury.

- Inspect the output shaft. The gear areas should be smooth and free from wear. Check the splines where the synchronizers are installed for wear and damage.
- Make sure the lubrication hole in the output shaft is clean and open. If it is clogged, blow through it or use a wire to open the passage.
- Check small parts such as shims and washers against specifications. If they are damaged or worn, replace them. Worn parts can allow incorrect output shaft end play, resulting in overloaded and damaged bearings.
- Use a magnifying glass to examine the output shaft gear teeth for damage or wear. Replace the gear if it is worn or even slightly damaged. Damaged teeth are dangerous in a transmission. Broken parts or metal particles can be carried by the lubricant between meshing gears and cause more damage. Broken gear teeth also reduce the torque-carrying capacity of the gears, increasing the stress (and the possibility of further damage) on the remaining teeth.
- Check the tapered surface on the output shaft gears—it should be smooth and undamaged.
- If any output shaft gear is replaced because of damage, the corresponding countershaft or reverse idler gear must also be replaced.
- Check any replacement parts against the old parts and make sure they are alike. Compare the number of gear teeth on new gears to those they are replacing.
- If any gear is damaged, make a special check of other gears in the transmission. There is an increased chance that other gears are also damaged.

- After inspection, lightly lubricate all parts with the correct transmission lubricant before beginning reinstallation.

- A soft-faced hammer or a steel hammer and a brass drift are usually the best tools to drive the parts onto the output shaft.

- Routinely replace all snap rings and drift pins before reassembly.

- Make sure snap rings fit tightly in their grooves.

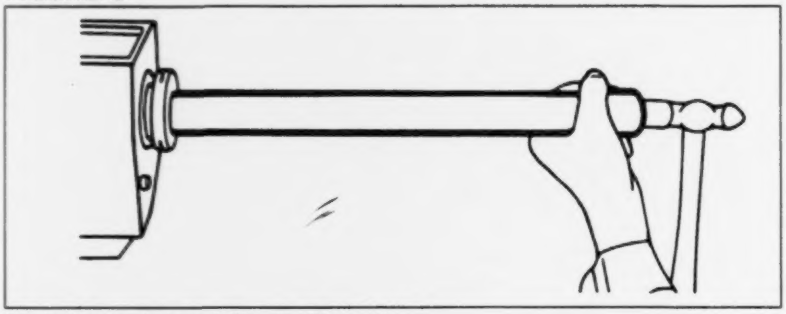
- Tighten any nuts to specifications.

- Assemble synchronizer assemblies before installing them on the output shaft. Make sure the sleeve and hub do not get separated during reinstallation, or you will have to remove them to get them back together. This is particularly true of ball type synchronizers.

- Lubricate the bore of speed gears before installing them. Gears should spin easily once they're replaced, but you shouldn't be able to rock them back and forth.

- When bearings are installed directly into the housing, coat the bearing-to-housing surfaces with a sealant before installation. Use a special driver to drive the bearing into the housing. (Figure 5)

FIGURE 5



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EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15H

Remove, inspect, and replace synchronizer assembly components.

INTRODUCTION

Synchronizers are the output shaft components which change the flow of power through the transmission. Their proper condition is critical to the operation of all other transmission parts. Synchronizers are also the most complicated component on an output shaft. Their removal, inspection, and replacement requires special care.

Although there are only two main types of synchronizers, the way they are removed and replaced on the output shaft and their placement on the shaft varies according to the transmission. The vehicle's service manual must be consulted for specific instructions.

Guidelines

- On some output shafts, if any synchronizer hub or sleeve needs to be replaced, the entire output shaft must be replaced as well.
- Hold the output shaft and try to rotate the synchronizer hub on the shaft. If there is any looseness at all, replace the entire synchronizer assembly.
- If the synchronizer assembly is worn between the sleeve and the keys, the transmission can slip out of gear. If the keys do not snap cleanly when the sleeve moves into neutral on the hub, the complete assembly should be replaced.
- Sometimes an arbor press is needed to remove and replace synchronizer hubs from the output shaft. Occasionally the hub must be heated before being pressed on the shaft.
- Mark the synchronizer hub and sleeve before disassembly so they can be replaced in the same position.
- Tag the synchronizer assembly with its position on the output shaft.
- Keep the synchronizer rings with the gears they mate with. Don't mix synchronizer rings between gears.
- Remove the springs and keys only after removing the sleeve from the hub.

- Clean all parts with a bristle brush and an approved cleaning solvent and blow dry with compressed air before inspection.
- Inspect the hub and sleeve splines for worn or damaged tips. The tips should be pointed.
- The synchronizer hub should not be bent, cracked, or have other signs of damage or wear.
- Make sure the synchronizer rings fit well on their speed gears.
- Check the teeth on the synchronizer ring for damage and wear.
- The grooves inside a synchronizer ring should be sharp so that they can cut through the lubricant on the speed gear cone. If they are dull, replace the ring.
- Place the synchronizer ring on a flat surface. It should sit flat.
- Springs should not be bent or distorted. Make sure the small bent end is not broken off.
- After inspection, lightly lubricate all parts with the correct transmission lubricant before beginning reinstallation.
- Springs and keys can be replaced without replacing the synchronizer hub and sleeve, but replace the hub and sleeve as a unit.
- When reinstalling synchronizers, remember that hubs are longer on the end that is installed toward the front of transmission than on the end that is toward the back.
- Make sure that the springs engage all three keys.
- Assemble synchronizer assemblies before installing them on the output shaft. Make sure the sleeve and hub do not get separated during reinstallation, or you will have to remove them to get them back together. This is particularly true of ball type synchronizers.
- Measure the distance between the synchronizer ring and the clutch teeth on its speed gear with a feeler gauge. Replace the synchronizer if the distance is not within specification.
- Check to make sure each synchronizer ring rotates freely and does not bind on its speed cone.

EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15I

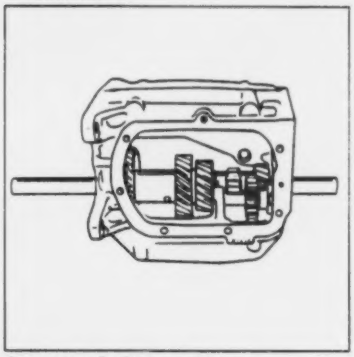
Remove, inspect, and replace countershaft assembly components.

INTRODUCTION

The countershaft is often the first transmission component moved from position when the transmission is disassembled. Although it usually cannot be removed from the transmission housing until the output shaft and input shaft are removed, the countershaft can be moved away from these shafts.

A short "dummy" shaft is driven directly into the end of the countershaft through the middle of the cluster gear. The dummy shaft drives the countershaft itself out the other end of the transmission housing. (Figure 1) Because the dummy shaft is shorter than the actual countershaft, the dummy shaft with the cluster gear attached falls into the bottom of the transmission housing. Now that the input shaft and output shaft gears are released from their constant mesh with the cluster gear, they can be removed much more easily.

FIGURE 1



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Although you must refer to the vehicle's service manual to complete this job sheet, here are some ideas that should be helpful:

Guidelines

- As you disassemble the countershaft, put the parts in order on the workbench for easier reassembly.
- After you remove the countershaft assembly from the transmission housing, inspect the housing for small parts from this assembly or other assemblies that may have fallen into the housing.
- Keep the needle bearings together in a plastic bag so they won't be confused with bearings from other assemblies. Needle and roller bearings often appear to be the same size, but are not.

- Keep caged bearings with their own bushings and tag them according to their location on the shaft.
- Check the needle bearings and races for wear and damage. If any bearing must be replaced, replace all the bearings at that location. If either a caged bearing or its bushing need replacement, replace both parts.
- Clean all parts with a bristle brush and an approved cleaning solvent and blow dry with compressed air before inspection.
- +/800 II/810/JetScriptQMPSJEII.PRS in the countershaft is clean and open. If it is clogged, blow through it or use a wire to open the passage.
- Check small parts such as shims and washers against specifications. If they are damaged or worn, replace them. Worn parts can allow incorrect countershaft shaft end play, resulting in overloaded and damaged bearings.
- Use a magnifying glass to examine the countershaft gear teeth for damage or wear. Replace the gear if it is worn or even slightly damaged.
- If any countershaft gear is replaced because of damage, the corresponding input shaft, output shaft, or reverse idler gear must also be replaced.
- Check any replacement parts against the old parts and make sure they are alike. Compare the number of gear teeth on new gears to those they are replacing.
- If any gear is damaged, make a special check of other gears in the transmission. There is an increased chance that other gears are also damaged.
- After inspection, lightly lubricate all parts with the correct transmission lubricant before beginning reinstallation.

- Coat the countershaft bore with petroleum jelly to hold the needle bearings in place during reassembly. Using chassis grease or other heavy grease will clog the lubricant holes, keeping lubricant from circulating during operation. (Figure 2)
- Routinely replace all oil seals, expansion plugs, and snap rings before reassembly.
- To install an expansion plug in the recess in the countershaft hole, hit the center of the plug with the round end of a ball peen hammer, and the plug will expand to fit the hole. The center of the plug should be flush or slightly below the surface of the housing. (Figure 3)

FIGURE 2

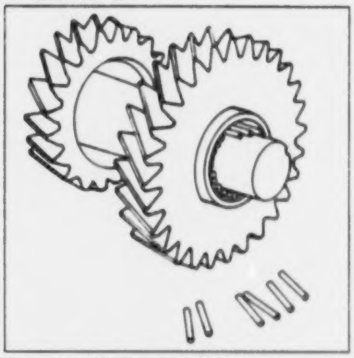

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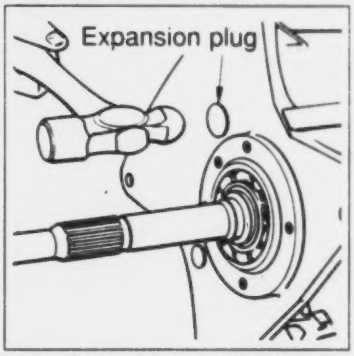
FIGURE 3



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EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15J

Remove, inspect, and replace reverse idler gear assembly components.

INTRODUCTION

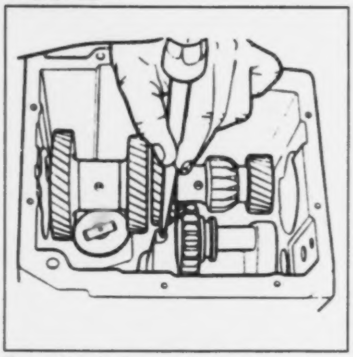
When a transmission is overhauled, the reverse idler gear assembly does not always need to be removed. The specialist can inspect the reverse idler gear without removing it from the housing, checking the gear teeth for wear or damage. If the gear assembly moves when wiggled back and forth on the shaft, some part of the assembly is loose, and the assembly must be removed and inspected.

If the manufacturer recommends that reverse idler gear end play be checked, check the end play even though your inspection showed that you do not need to remove the reverse idler gear. If the end play is not within specifications, you will need to remove the reverse idler gear assembly to make the end play correction.

Guidelines

- As you disassemble the countershaft, put the parts in order on the workbench for easier reassembly.
- Use a drift punch to remove drift pins if they are used to secure the reverse idler shaft. (Figure 1)

FIGURE 1



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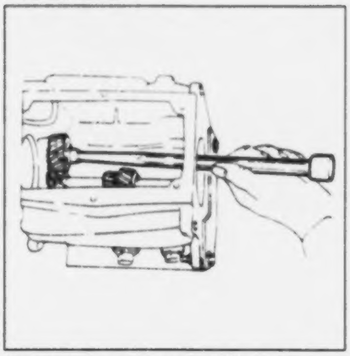
- Sometimes a long brass punch can be used to drive the reverse idler shaft out of the transmission housing. (Figure 2)
- Keep the needle bearings together in a plastic bag so they won't be confused with bearings from other assemblies. Needle and roller bearings often appear to be the same size but are not.

FIGURE 2



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- Check the needle bearings and races for wear and damage. If any bearing must be replaced, replace all the bearings at that location. If either a caged bearing or its bushing need replacement, replace both parts.
- Clean all parts with a bristle brush and an approved cleaning solvent and blow dry with compressed air before inspection.
- Inspect the reverse idler gear shaft to make sure it is not worn, bent, or damaged.
- Make sure the lubrication hole in the reverse idler gear shaft is clean and open. If it is clogged, blow through it or use a wire to open the passage.
- Check small parts such as shims and washers against specifications. If they are damaged or worn, replace them. Worn parts can allow incorrect reverse idler shaft end play, resulting in overloaded and damaged bearings.
- Use a magnifying glass to examine the reverse idler gear teeth for damage or wear. Replace the gear if it is worn or even slightly damaged.
- If the reverse idler gear is replaced because of damage, both the corresponding countershaft gear and output shaft gear must also be replaced.
- Check any replacement parts against the old parts and make sure they are alike. Compare the number of gear teeth on new gears to those they are replacing.
- If any gear is damaged, make a special check of other gears in the transmission. There is an increased chance that other gears are also damaged.

- After inspection, lightly lubricate all parts with the correct transmission lubricant before beginning reinstallation.

- Routinely replace any drift pins, expansion plugs, and seals before reassembly.

EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 11

SERVICE MANUAL TRANSMISSIONS

IV

OBJECTIVE 15K

Check and adjust end play in transmission shafts.

INTRODUCTION

There are four different shaft assemblies in a manual transmission: (1) input shaft, (2) output shaft, (3) countershaft, and (4) reverse idler gear shaft. It is important that the gears on each of these shafts mesh exactly if the transmission is to operate properly. During a transmission overhaul, manufacturers recommend that shaft end play be checked to make sure the components are meshing properly and will not move out of place.

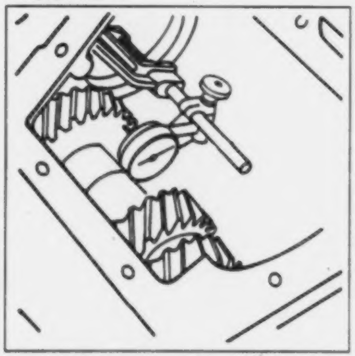
In the vehicle's service manual the manufacturer will tell you:

- Which shafts to check for end play
- Where to measure for end play
- The specifications for end play allowance
- Which method to use for making the end play measurements.
- How to adjust end play

NOTE: Shaft end play is checked by using one of two methods—a set of feeler gauges or a dial indicator. (Figure 1) See Supplement 8, Unit 1, "Using a Dial Indicator," to help you make an end play measurement with a dial indicator.

If an end play adjustment is needed, usually different size shims, spacers, snap rings, or thrust washers are used to increase or decrease the end play.

FIGURE 1



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EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15L **Clean and inspect the transmission housing and transmission housing components.**

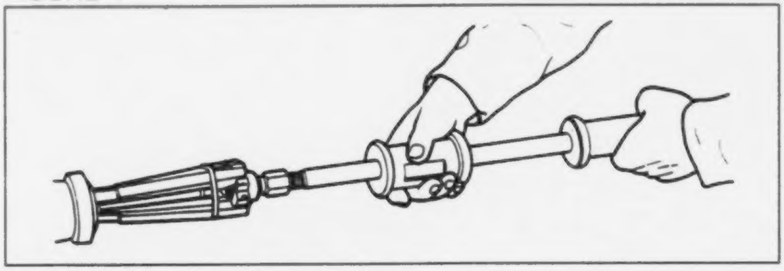
INTRODUCTION Before reassembling the transmission, the transmission housing and its parts should be cleaned and inspected. The exact procedure will depend upon the transmission you are working on. See the vehicle's service manual.

Guidelines

- Remove any trace of old gasket material and clean the sealing surfaces with mineral spirits or carbon tetrachloride.
- Some transmissions have a magnet in the bottom to help attract metal chips and particles. Clean the magnet with solvent.
- Steam clean the transmission housing or clean it with a stiff brush and an approved cleaning solvent. Allow it to air dry.
- Inspect the housing for cracks, porosity, or damage and replace the housing if any are found.
- If there is a center support plate, inspect it for cracks or damage.
- If any thread bores are stripped out, repair them with a thread repair kit.
- Check all surfaces that mate with another surface. If there are any burrs or deep gouges that could cause an oil leak, file off the burrs or high points.
- Inspect the bushing (or bearing) in the transmission extension housing and use a suitable driver to remove and replace it if necessary. When replacing a bushing, make sure the oil hole is aligned with any oil slot in the housing.

- Routinely remove and replace the rear oil seal. (Figure 1) Use the proper tools to remove and replace the seal and lubricate the seal before installation.

FIGURE 1



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EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 15M

Assemble the transmission and complete transmission service.

INTRODUCTION

Usually the steps necessary to assemble the transmission are the reverse of the disassembly process—you must check the service manual to make sure. However, many tasks involved in assembling the transmission and completing transmission service are similar, and the following guidelines should be used.

Guidelines

- Make sure the transmission housing and all other transmission components have been inspected and cleaned and all damaged or worn parts have been repaired or replaced. (See previous job sheets.)
- Check shaft end play at the appropriate time during the assembly process. (Job Sheet 11)
- Before assembling transmission components, make sure they are all well lubricated.
- Be careful not to damage the transmission housing by overtightening mounting bolts. Use flat washers under all bolts, nuts, or studs. Aluminum is softer than the bolts. Torque to specifications.
- Apply a thread-locking compound to all transmission bolts before torquing them to specification.
- Install new gaskets or liquid sealant when completing assembly. If there is a problem holding gaskets in place during assembly, use petroleum jelly to hold them.
- Before reinstalling the assembled transmission in the vehicle, shift the gear shift lever through all gears, turning the input shaft by hand. It should shift into each gear easily. Check to make sure the output shaft turns appropriately with each gear shift. If the transmission does not shift correctly, disassemble the transmission and recheck and adjust the assembly.

CAUTION

If all parts have not been coated with transmission lubricant, shifting through the gears can damage the transmission.

- Refill the transmission with the correct lubricant after reinstalling the transmission in the vehicle.

EQUIPMENT AND MATERIALS

- Manual transmission from a front-engine, rear-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 1

Inspect, replace, and adjust the external shift linkage parts located outside the transmission case.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Properly prepared the vehicle.	_____	_____
4. Inspected and replaced shift linkage parts according to outlined procedures.	_____	_____
5. Adjusted and lubricated the shift linkage according to steps outlined in the appropriate service manual.	_____	_____
6. Tested the linkage adjustment correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Inspect and replace transmission mounts.

STUDENT'S NAME ______________________ DATE ______________

EVALUATOR'S NAME ______________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Properly prepared the vehicle.	_____	_____
4. Removed and cleaned the transmission mount correctly.	_____	_____
5. Inspected the transmission mount according to the outlined procedures.	_____	_____
6. Replaced the transmission mount correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE MANUAL TRANSMISSIONS

JOB SHEET 3

Disassemble a transmission.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared and cleaned the transmission.	_____	_____
3. Disassembled the transmission following the appropriate service manual.	_____	_____
4. Followed the guidelines recommended in the job sheet.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Remove, inspect, and replace external shift assembly components located inside the transmission housing.

STUDENT'S NAME ______________ DATE ________

EVALUATOR'S NAME ______________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student: .	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly prepared the transmission.	____	____
3. Removed and inspected the external shift assembly parts following the appropriate service manual.	____	____
4. Replaced the external shift assembly following the appropriate service manual.	____	____
5. Followed the guidelines recommended in the job sheet.	____	____
6. Observed safety rules and precautions.	____	____
7. Cleaned work area and return equipment and material to proper storage.	____	____

EVALUATOR'S COMMENTS

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 5

Remove, inspect, and replace internal shift assembly components.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transmission.	_____	_____
3. Removed and inspected the internal shift assembly components following the appropriate service manual.	_____	_____
4. Replaced the internal shift assembly following the appropriate service manual.	_____	_____
5. Followed the guidelines recommended in the job sheet.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and return equipment and material to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Remove, inspect, and replace input shaft assembly components.

STUDENT'S NAME ________________ DATE __________

EVALUATOR'S NAME ________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly prepared the transmission.	____	____
3. Removed input shaft assembly components following the appropriate service manual.	____	____
4. Inspected input shaft assembly components following the appropriate service manual.	____	____
5. Replaced input shaft assembly components following the appropriate service manual.	____	____
6. Followed the guidelines recommended in the job sheet.	____	____
7. Observed safety rules and precautions.	____	____
8. Cleaned work area and return equipment and material to proper storage.	____	____

EVALUATOR'S COMMENTS ____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 7

Remove, inspect, and replace output shaft assembly components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transmission.	_____	_____
3. Removed output shaft assembly components following the appropriate service manual.	_____	_____
4. Inspected output shaft assembly components following the appropriate service manual.	_____	_____
5. Replaced output shaft assembly components following the appropriate service manual.	_____	_____
6. Followed the guidelines recommended in the job sheet.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and return equipment and material to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 8

Remove, inspect, and replace synchronizer assembly components.

STUDENT'S NAME ______________ DATE ____________

EVALUATOR'S NAME ______________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transmission.	_____	_____
3. Removed synchronizer assembly components following the appropriate service manual.	_____	_____
4. Inspected synchronizer assembly components following the appropriate service manual.	_____	_____
5. Replaced synchronizer assembly components following the appropriate service manual.	_____	_____
6. Followed the guidelines recommended in the job sheet.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and return equipment and material to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 9

Remove, inspect, and replace countershaft assembly components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transmission.	_____	_____
3. Removed countershaft assembly components following the appropriate service manual.	_____	_____
4. Inspected countershaft assembly components following the appropriate service manual.	_____	_____
5. Replaced countershaft assembly components following the appropriate service manual.	_____	_____
6. Followed the guidelines recommended in the job sheet.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 10

Remove, inspect, and replace reverse idler gear assembly components.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly prepared the transmission.	____	____
3. Inspected the reverse idler gear assembly components following the appropriate service manual.	____	____
4. Decided correctly whether or not the reverse idler gear assembly needed to be removed.	____	____
5. If necessary, removed the reverse idler gear assembly components following the appropriate service manual.	____	____
6. Inspected and replaced the reverse idler gear assembly components following the appropriate service manual.	____	____
7. Followed the guidelines recommended in the job sheet.	____	____
8. Observed safety rules and precautions.	____	____
9. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TESTS

SERVICE MANUAL TRANSMISSIONS IV

JOB SHEET 11

Check and adjust end play in transmission shafts.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transmission.	_____	_____
3. Checked end play in the transmission shafts following the appropriate service manual.	_____	_____
4. Adjusted end play in the transmission shafts following the appropriate service manual.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 12 **Clean and inspect the transmission case and transmission case components.**

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly prepared the transmission.	____	____
3. Cleaned the transmission case following the appropriate service manual.	____	____
4. Inspected the transmission case following the appropriate service manual.	____	____
5. Followed the guidelines recommended in the job sheet.	____	____
6. Observed safety rules and precautions.	____	____
7. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

____

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 13

Assemble the transmission and complete transmission service.

STUDENT'S NAME ________________ DATE ____________

EVALUATOR'S NAME ________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transmission.	_____	_____
3. Assembled the transmission following the appropriate service manual.	_____	_____
4. Completed transmission service correctly.	_____	_____
5. Followed the guidelines recommended in the job sheet.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE MANUAL TRANSMISSIONS

NAME ______________________________ SCORE ______

OBJECTIVE 1

Choose the correct definitions for terms associated with the automotive manual transmission by selecting the correct definition from four choices. Select the best answer for each term.

______1. **cluster gear**

A. One of a group of gears
B. Any gear on the transmission countershaft
C. A single part on which several gears of different sizes have been machined from a single piece of metal
D. Any gear in the "cluster" of transmission gears

______2. **constant mesh gears**

A. Gears which move back and forth on their shaft to mesh with another gear or gears
B. Gears which mesh at a constant gear ratio
C. Gears which mesh at a constant speed
D. Gears which mesh at all times

______3. **foot-pound**

A. The weight of one square foot of any substance
B. A measure of force representing the torque exerted when the circumference of any gear travels one foot
C. A measure of torque which represents the amount of force required to lift one pound a distance of one foot
D. A measure of the distance any gear must travel to propel the vehicle one foot

______4. **gasket**

A. Sealing material used to form a tight seal between two parts
B. A spring steel ring containing a small opening which allows it to fit over a shaft to hold parts in place
C. A rubber ring used to form a seal
D. A watertight cover

______5. **high gear**

A. The gear on the vehicle with the highest gear number
B. The largest transmission gear
C. The transmission gear on the vehicle which produces the maximum road speed
D. The transmission gear which produces the slowest road speed

______6. **low gear**

A. The transmission gear on the vehicle which produces the maximum road speed
B. The transmission gear on the vehicle which produces the slowest forward road speed
C. The transmission gear on the vehicle which produces the slowest road speed
D. The smallest transmission gear

______7. **neutral**

A. The position in the transmission that exists when all transmission gears are disengaged
B. The condition in the transmission that exists when no gears are turning
C. The drivetrain condition when no power is flowing into the transmission
D. The automotive condition that exists when the vehicle is not moving

______8. **overdrive**

A. The highest gear ratio in the transmission
B. A gear ratio which allows the output shaft to turn faster than the input shaft
C. A gear ratio which allows the output shaft to turn slower than the input shaft
D. High gear in any vehicle

______9. **overhaul**

A. A condition that exists when the transmission is overloaded
B. A procedure by which a worn or damaged assembly or part is completely replaced
C. A procedure in which an assembly is adjusted for accurate operation
D. A procedure in which an assembly is completely disassembled, cleaned, inspected, repaired, reassembled, and adjusted for proper operation

_____10. **sliding gear**

A. A gear which moves back and forth on its shaft to mesh with another gear or gears
B. A gear which changes its gear ratio by sliding back and forth on its shaft, meshing with different countershaft gears
C. A constant mesh gear which slides out of the way when not in use
D. The gear in a gear set which distributes lubricant to the other gears

_____11. **snap ring**

A. A gasket which fits between parts on a shaft
B. A spring steel ring containing a small opening which allows it to fit over a shaft to hold parts in place
C. A type of washer which fits on a transmission shaft and acts as a spacer between parts on the shaft
D. A circular spring which fits on a transmission shaft to reduce transmission shaft end play

_____12. **synchronize**

A. To cause events to happen at the same time
B. To cause events to happen one after another
C. To organize in order
D. To time events in order

_____13. **torque multiplication**

A. The increase in power which occurs when the driven gear is smaller than the driving gear
B. The increase in power which occurs when the driven gear is larger than the driving gear
C. The increase in power which occurs naturally through inertia
D. Any change in the direction of torque that is supplied to the drive wheels

OBJECTIVE 2 **Identify common driving situations which require greater torque and those which require less torque.** Write **"Greater"** in front of the following situations which require greater than normal torque and **"Less"** in front of the situations which require less than normal torque.

_____________1. Go downhill

_____________2. Drive on a smooth road

_____________3. Carry a heavy load

_____________4. Move the vehicle from a standing start

_____________5. Carry no extra load

_____________6. Drive into a head wind

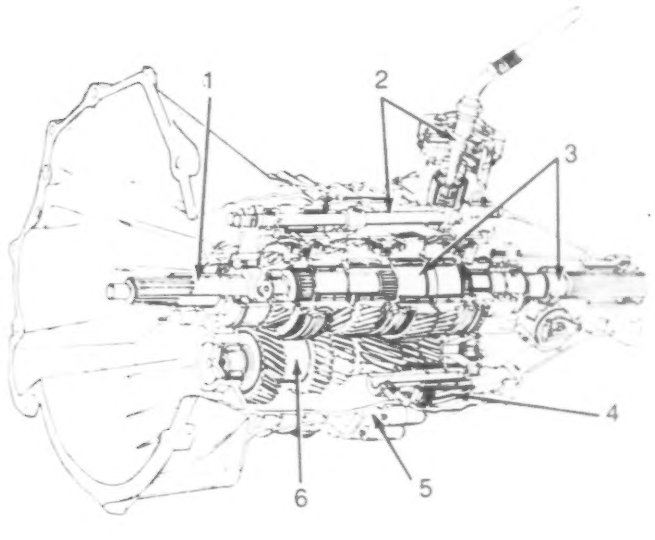
_____________7. Climb a hill

_____________8. Keep the vehicle moving after it has established speed

_____________9. Drive with a tail wind

_____________10. Drive on a rough road

OBJECTIVE 3 **Label the basic parts of a transmission on an illustration.** Put the name of the part indicated by the corresponding blank.



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1. ______________________________

2. ______________________________

3. ______________________________

4. ____

5. ____

6. ____

OBJECTIVE 4

Match the names of the basic parts of a transmission to a description of their functions. Place the number of the correct term in the blank in front of the description of the function.

______1. Allows the driver to change the transmission gear to adjust to different driving conditions

______2. Accepts torque from the clutch and transfers it to the countershaft assembly

______3. Protects the transmission and provides a mounting surface for transmission parts

______4. Transfers torque to the reverse idler gear and all the gears on the output shaft

______5. Changes the direction of the torque to allow the vehicle to move in reverse

______6. The gears and synchronizers on this shaft increase or decrease the torque and transfer it to the vehicle's driveline

A. Countershaft assembly

B. Input shaft assembly

C. Output shaft assembly

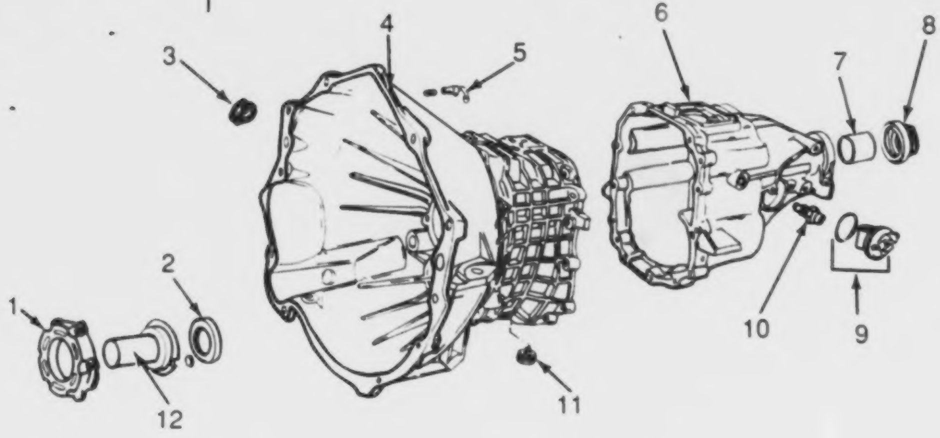
D. Reverse idler gear assembly

E. Shift linkage

F. Transmission housing

OBJECTIVE 5

Match the names of the parts of a transmission housing to an illustration. Write the letter of the correct part in the blank.



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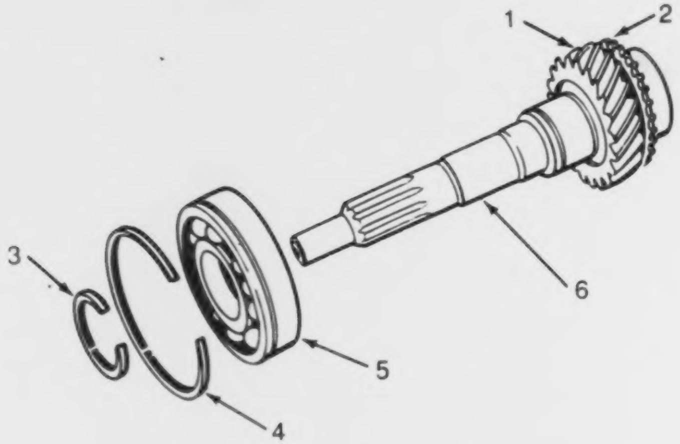
_______1.
_______2.
_______3.
_______4.
_______5.
_______6.
_______7.
_______8.
_______9.
______10.
______11.
______12.

A. Back-up light switch
B. Front transmission housing
C. Input shaft bearing retainer
D. Input shaft oil seal
E. Oil drain plug
F. Oil fill plug
G. Rear bearing extension
H. Rear transmission housing
I. Retainer sleeve
J. Slip yoke oil seal
K. Speed sensor assembly
L. Vent

OBJECTIVE 6 **Label the parts of an input shaft assembly on an illustration.**

Put the name of the part indicated by the corresponding blank.



Used with permission of Ford Motor Company.

1. ____

2. ____

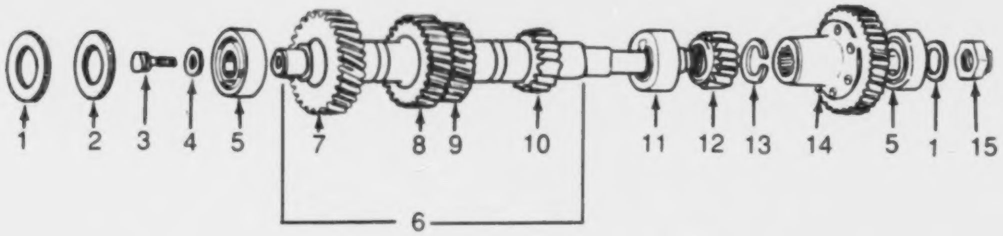
3. ____

4. ____

5. ____

6. ____

OBJECTIVE 7 **Match the names of the parts of a countershaft assembly to an illustration.** Write the letter of the correct part in the blank.

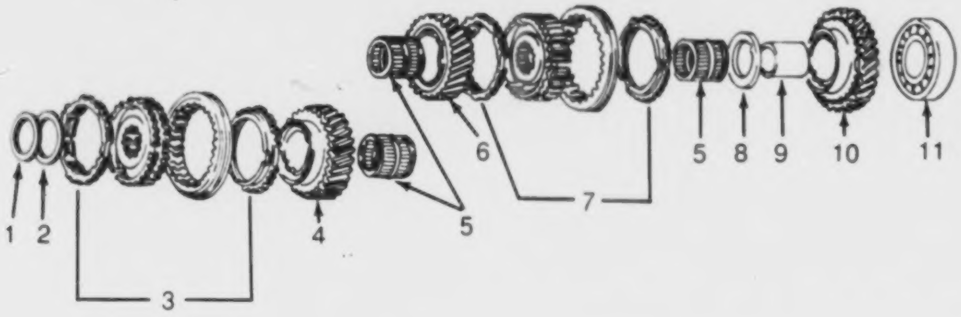


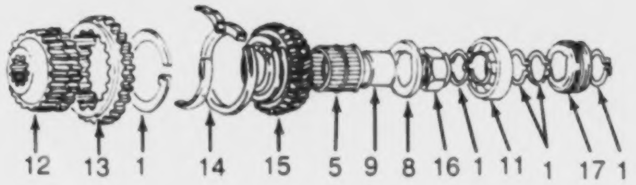
Used with permission of Toyota Motor Sales, U.S.A.

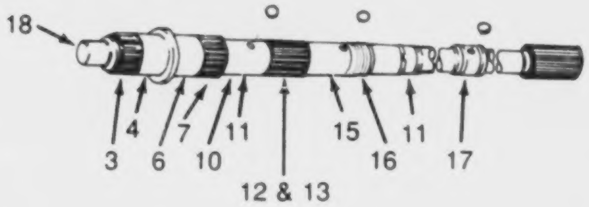
______1.
______2.
______3.
______4.
______5.
______6.
______7.
______8.
______9.
______10.
______11.
______12.
______13.
______14.
______15.

A. Ball bearing
B. Bolt with washer
C. Cluster gear
D. Cluster gear 1st gear
E. Cluster gear 2nd gear
F. Cluster gear 3rd gear
G. Cluster input gear
H. Countershaft reverse gear
I. Countershaft 5th gear
J. Nut
K. Roller bearing
L. Shim
M. Snap ring
N. Thrust washer
O. Washer

OBJECTIVE 8 **Match the names of the parts of an output shaft to an illustration.** Write the letter of the correct part in the blank.


1
2
3
4
5
6
7
5
8
9
10
11


12
13
1
14
15
5
9
8
16
1
11
1
17
1


18
4
7
11
3
6
10
15
11
16
17
12 & 13

Used with permission of Nissan Motor Co., LTD.

_______1. A. Ball bearing

_______2. B. Bushing

_______3. C. Caged needle bearings

_______4. D. 1st gear

_______5. E. 2nd gear

_______6. F. 3rd gear

______7. G. 5th gear

______8. H. 1st and 2nd gear synchronizer assembly

______9. I. 3rd and 5th gear synchronizer assembly

______10. J. Output shaft

______11. K. Output shaft nut

______12. L. Sliding reverse gear

______13. M. Snap ring

______14. N. Speedometer drive gear

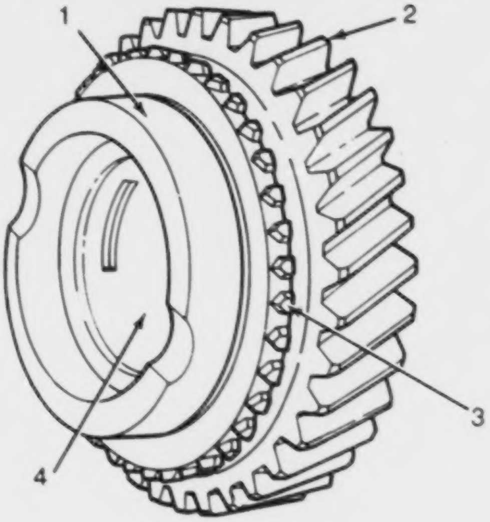
______15. O. Synchronizer hub

______16. P. Synchronizer ring

______17. Q. Thrust washer

______18. R. Washer

OBJECTIVE 9 **Label the parts of a speed gear on an illustration.** Write the name of the part indicated by the corresponding blank.



Used with permission of Chrysler Corporation.

1. ____

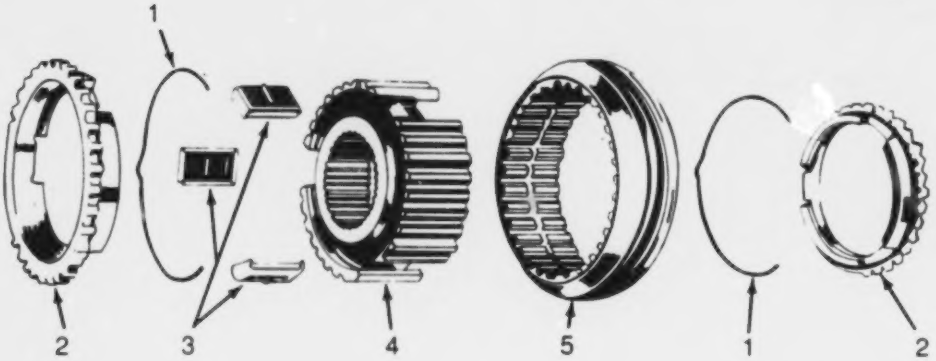
2. ____

3. ____

4. ____

OBJECTIVE 10

Label two types of synchronizer assemblies and their parts on illustrations. Write the type of synchronizer in the first blank and the name of the part indicated by the corresponding blank.



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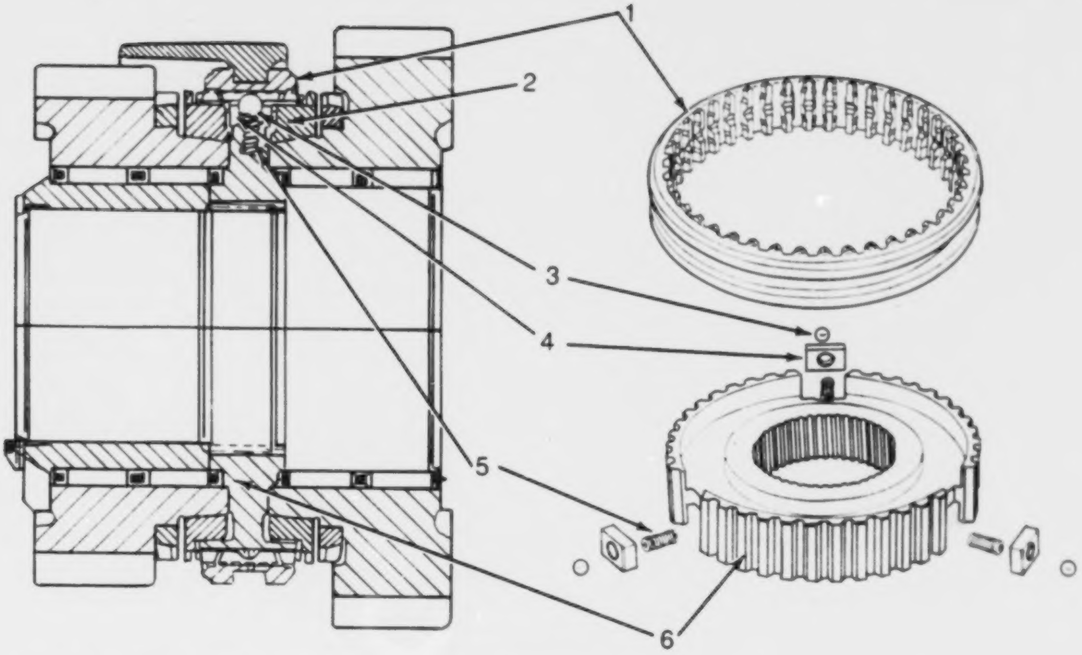
A. Type of Synchronizer: ______________________

Parts:

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________



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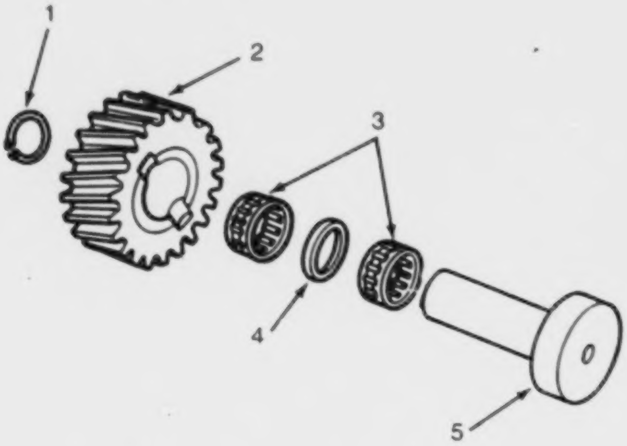
B. Type of Synchronizer: ______________________________

Parts:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

OBJECTIVE 11

Label the parts of a reverse idler gear assembly on an illustration. Put the name of the part indicated by the corresponding blank.



Used with permission of Chrysler Corporation.

1. ______________________________

2. ______________________________

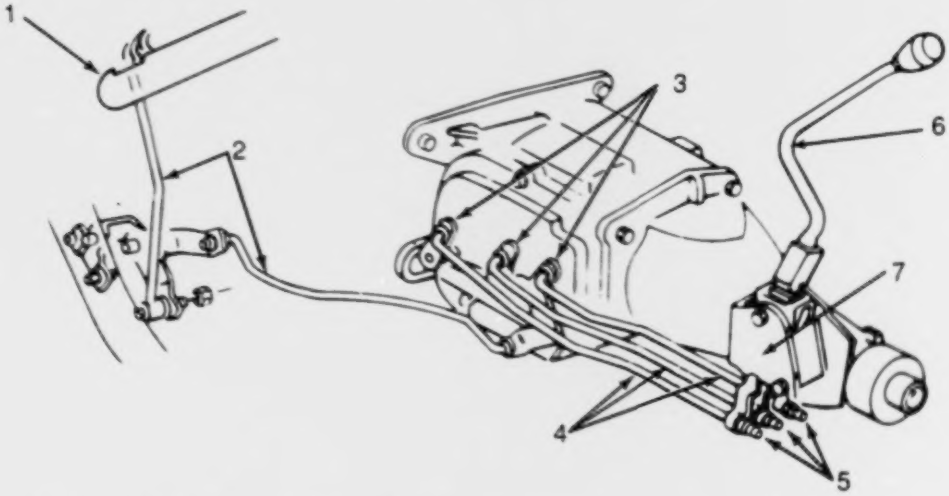
3. ______________________________

4. ______________________________

5. ______________________________

OBJECTIVE 12

Label the two types of transmission shift linkages and match the names of their basic parts to illustrations. Write the type of shift linkage in the first blank and the letter of the correct part in the smaller blank.



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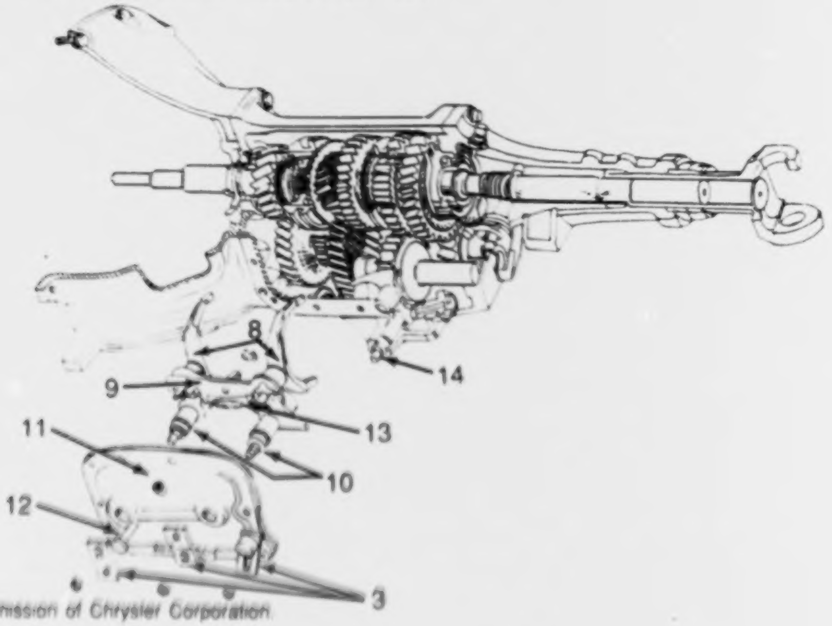


Used with permission of Chrysler Corporation.

A. Type of Shift Linkage: ______________________________

______1. A. Detent cam shaft

______2. B. Detent cams

______3. C. Detent spring

______4. D. Gear shift lever

______5. E. Gear shift lever bracket

______6. F. Linkage rod levers

______7. G. Shift cover

______8. H. Shift forks

______9. I. Shift linkage rods

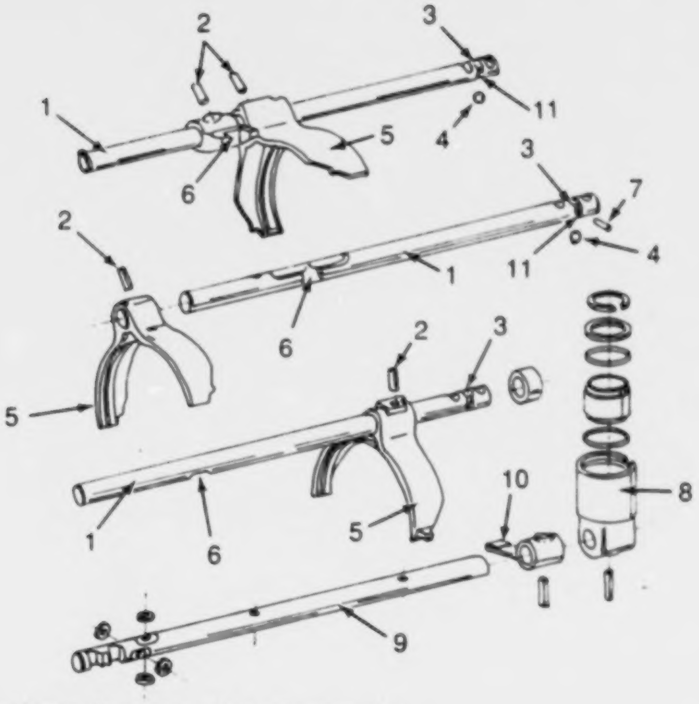
_____10: J. Shifter arms

_____11. K. Shifter shaft for reverse

_____12. L. Shifter shafts

_____13. M. Steering column

_____14. N. Transmission lock rod



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B. Type of shift linkage: ______________________________

______1.

______2.

______3.

______4.

______5.

______6.

______7.

______8.

______9.

_____10.

_____11.

A. Drift pin

B. Gear shift lever tower

C. Interlock ball

D. Interlock pin

E. Notch contacted by shift shaft finger to move shift fork

F. Notch for interlock balls

G. Notch for shift detent balls

H. Shift fork

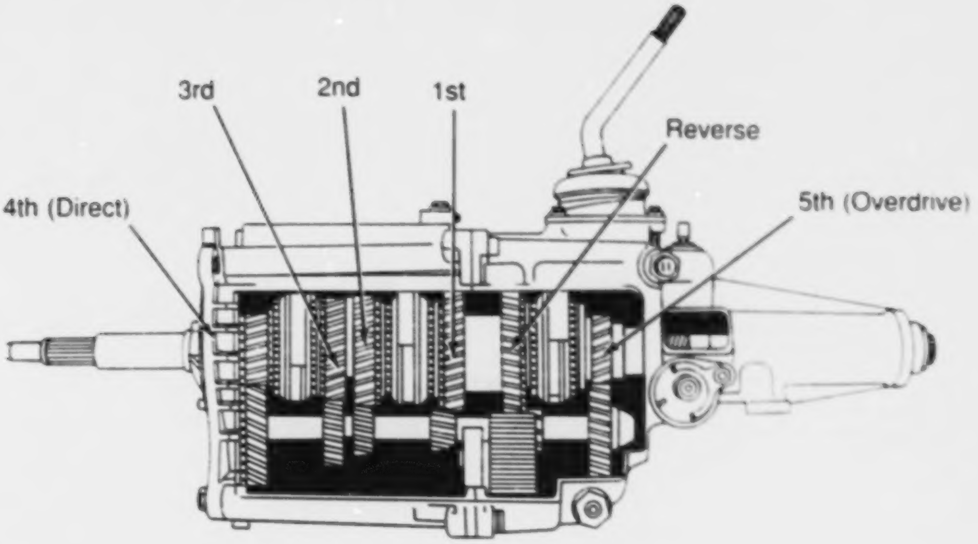
I. Shift rail

J. Shift shaft

K. Shift shaft finger

OBJECTIVE 13 **Trace the flow of power through each gear setting on illustrations of a five-speed transmission.** Use a pen or pencil to draw a line tracing the flow of power through the illustration for the given gear.

NEUTRAL


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

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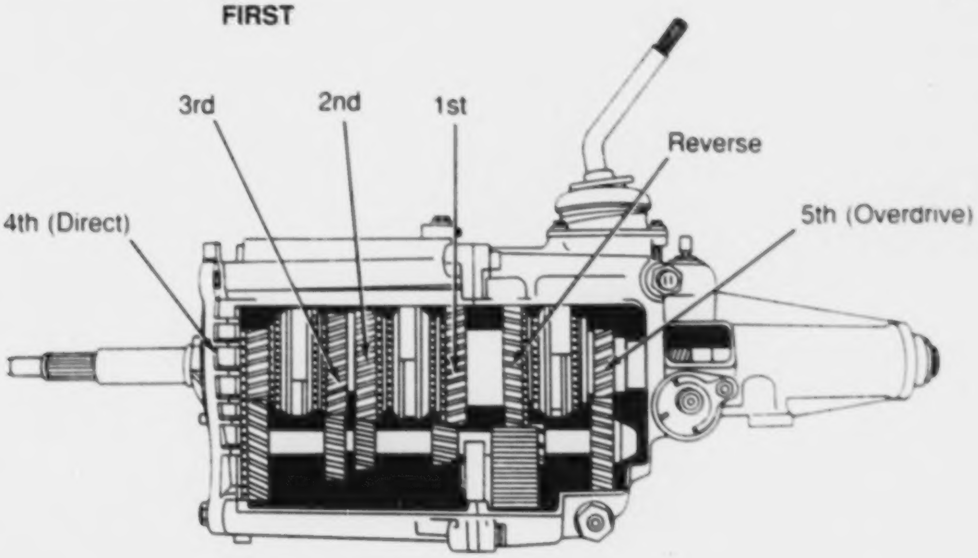
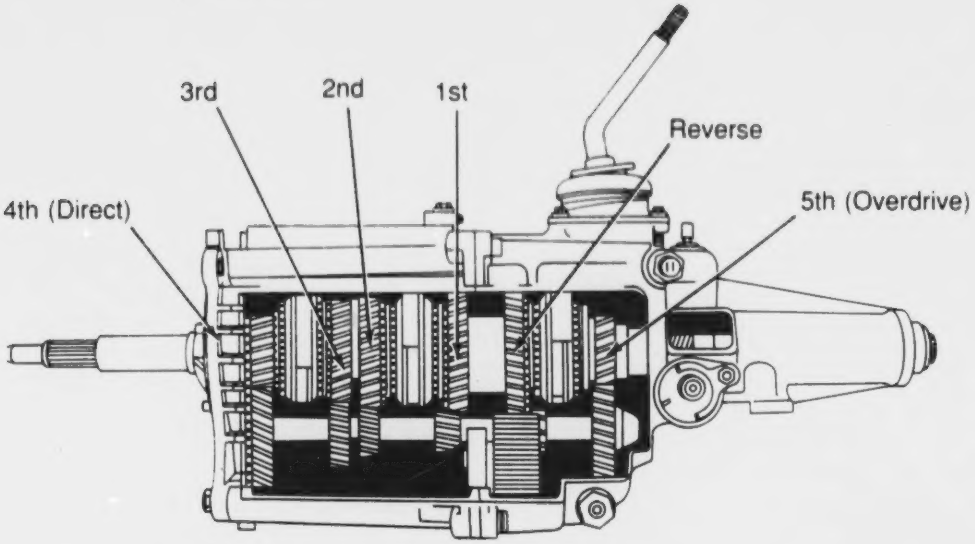
FIRST


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

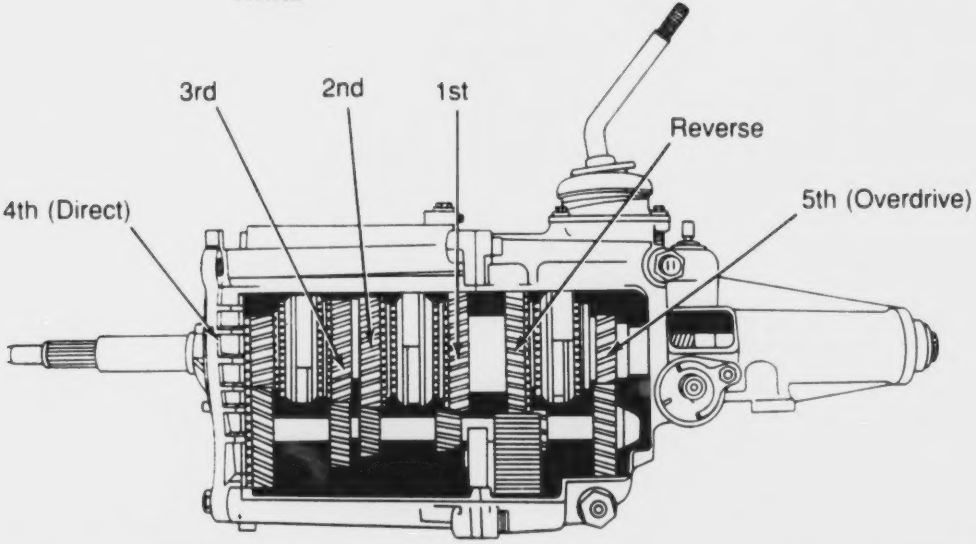
Used with permission of Chrysler Corporation.

SECOND


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

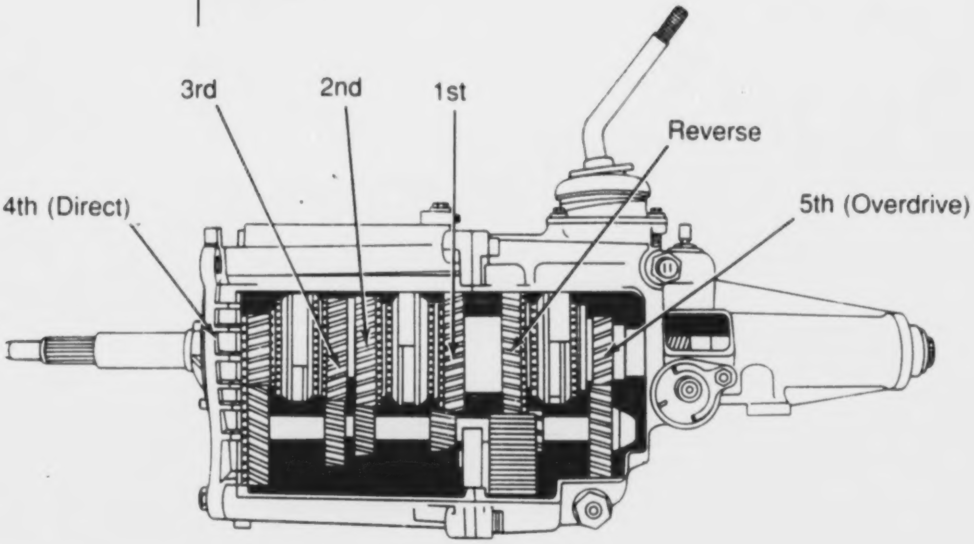
Used with permission of Chrysler Corporation.

THIRD


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

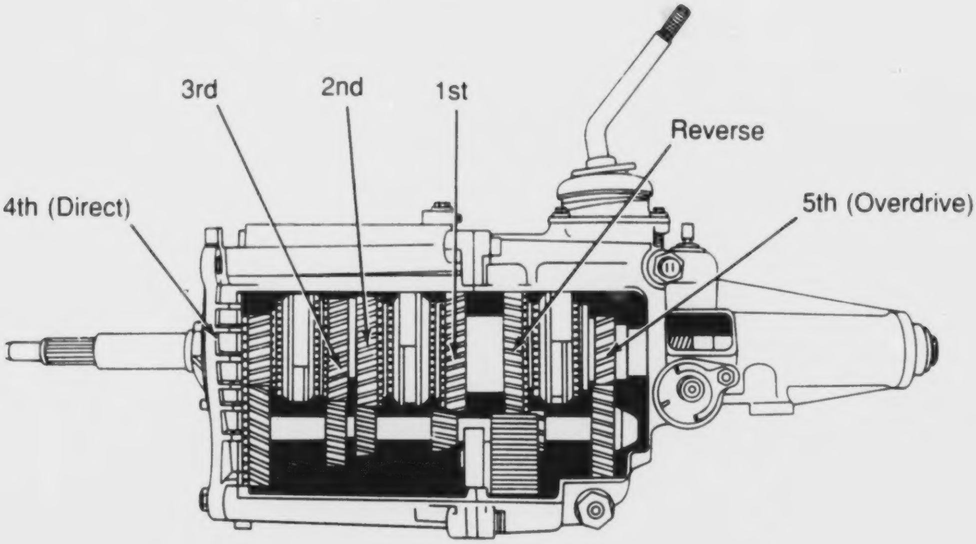
Used with permission of Chrysler Corporation.

FOURTH


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

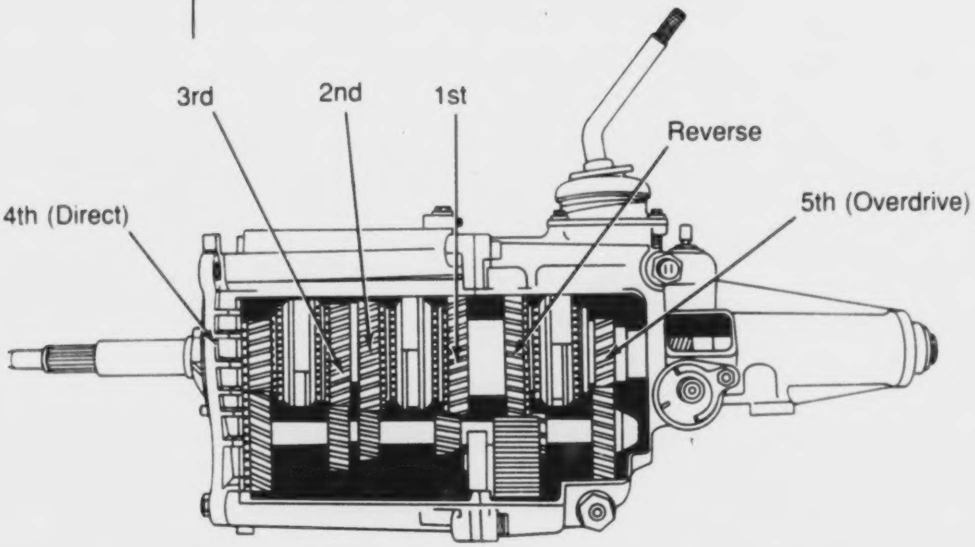
Used with permission of Chrysler Corporation.

FIFTH (OVERDRIVE)


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

Used with permission of Chrysler Corporation.

REVERSE


3rd
2nd
1st
Reverse
4th (Direct)
5th (Overdrive)

Used with permission of Chrysler Corporation.

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OBJECTIVE 1

1. C
2. D
3. C
4. A
5. C
6. B
7. A
8. B
9. D
10. A
11. B
12. A
13. B

OBJECTIVE 2

1. Less
2. Less
3. Greater
4. Greater
5. Less
6. Greater
7. Greater
8. Less
9. Less
10. Greater

OBJECTIVE 3

1. Input shaft assembly
2. Shift linkage
3. Output shaft assembly
4. Reverse idler gear assembly
5. Transmission housing
6. Countershaft assembly

OBJECTIVE 4

1. E
2. B
3. F
4. A
5. D
6. C

OBJECTIVE 5

1. C
2. D
3. F
4. B
5. L
6. H
7. G
8. J
9. K
10. A
11. E
12. I

OBJECTIVE 6

1. Input gear
2. Clutch teeth
3. Selective snap ring
4. Snap ring
5. Bearing
6. Input shaft

OBJECTIVE 7

1. L
2. N
3. B
4. O
5. A
6. C
7. G
8. F
9. E
10. D
11. K
12. H
13. M
14. I
15. J

OBJECTIVE 8

1. M
2. R
3. I
4. F
5. C
6. E
7. H
8. Q
9. B
10. D
11. A
12. O
13. L
14. P
15. G
16. K
17. N
18. J

OBJECTIVE 9

1. Cone
2. Helical gear teeth
3. Clutch teeth
4. Bore

OBJECTIVE 10

A. Key Type Synchronizer

   1. Spring
   2. Synchronizer ring
   3. Keys
   4. Synchronizer hub
   5. Synchronizer sleeve

B. Ball Type Synchronizer

   1. Synchronizer sleeve
   2. Synchronizer ring
   3. Ball
   4. Key
   5. Spring
   6. Synchronizer hub

OBJECTIVE 11

1. Selective snap ring
2. Reverse idler gear
3. Caged needle bearings
4. Spacer
5. Reverse idler gear shaft

OBJECTIVE 12

A. External shift linkage

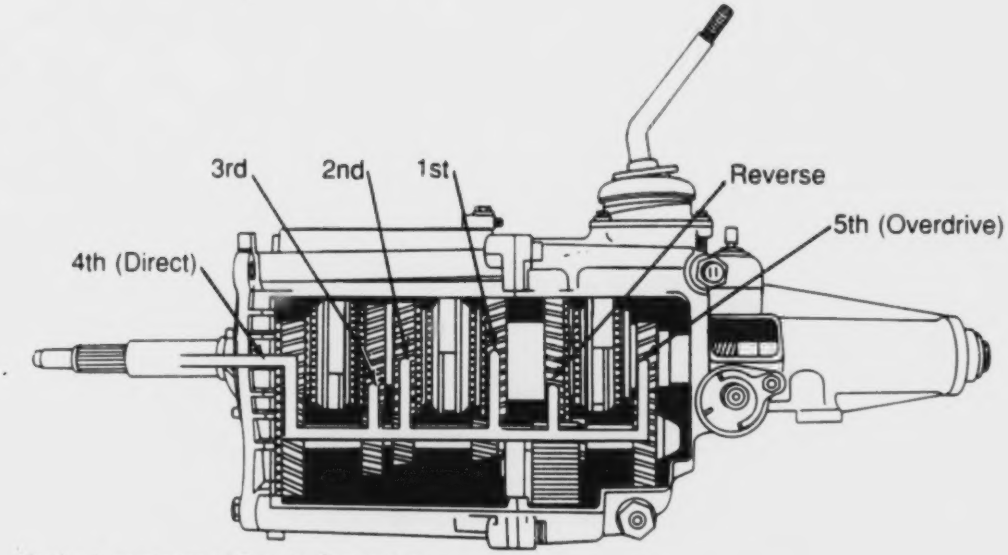
1. M
2. N
3. J
4. I
5. F
6. D
7. E
8. H
9. B
10. L
11. G
12. A
13. C
14. K

B. Internal shift linkage

1. I
2. A
3. G
4. C
5. H
6. E
7. D
8. B
9. J
10. K
11. F

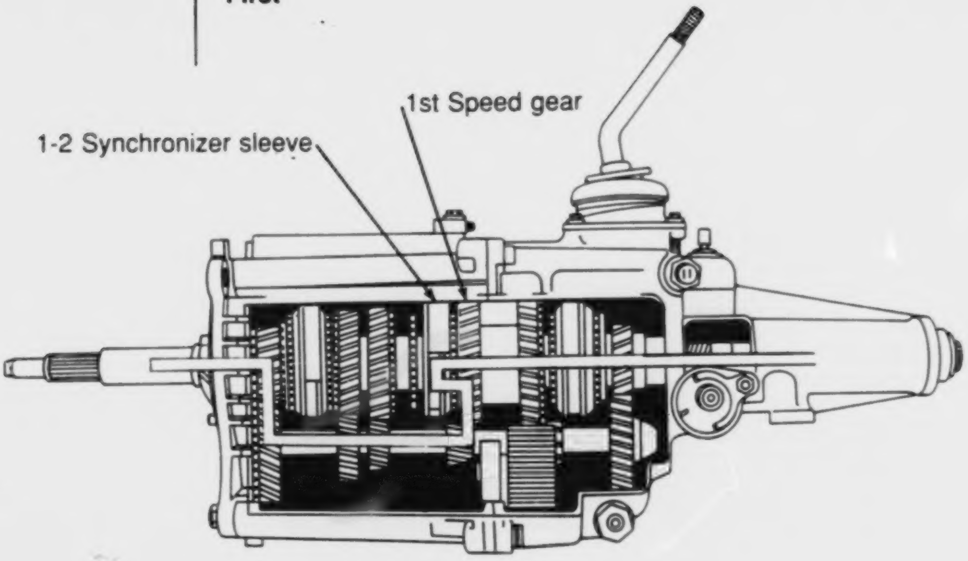
OBJECTIVE 13

Neutral


3rd
2nd
1st
Reverse
5th (Overdrive)
4th (Direct)

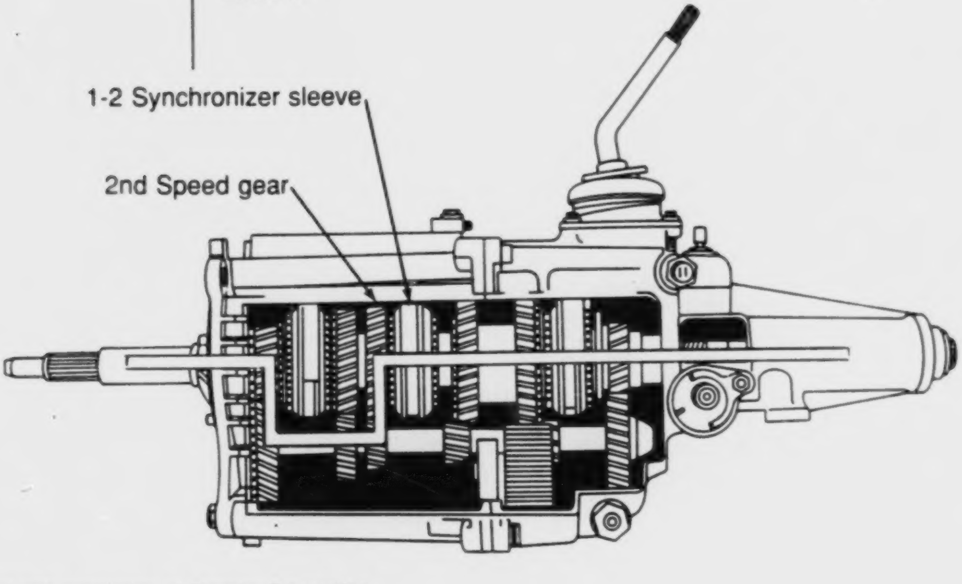
Used with permission of Chrysler Corporation.

First


1st Speed gear
1-2 Synchronizer sleeve

Used with permission of Chrysler Corporation.

Second


1-2 Synchronizer sleeve
2nd Speed gear

Used with permission of Chrysler Corporation.

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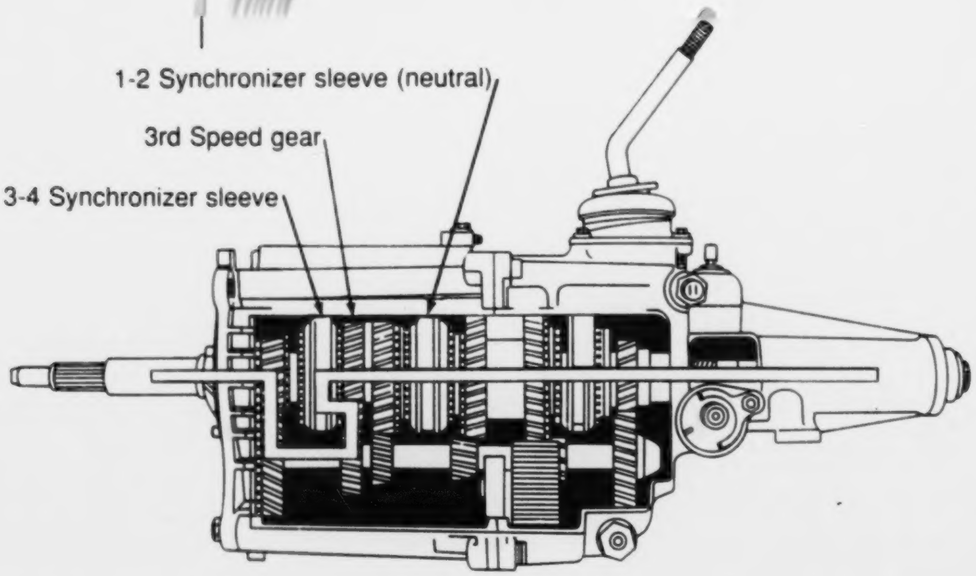
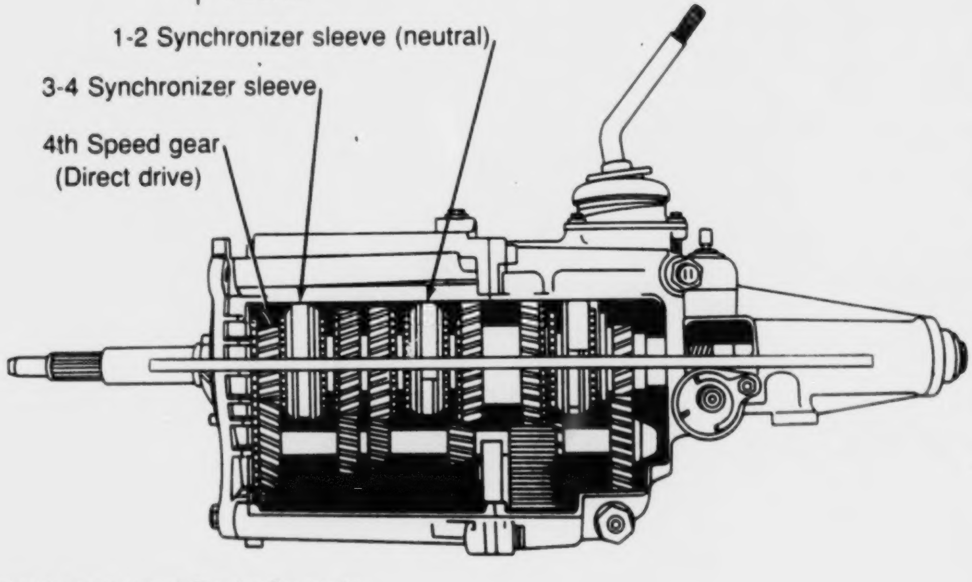
Third


1-2 Synchronizer sleeve (neutral)
3rd Speed gear
3-4 Synchronizer sleeve

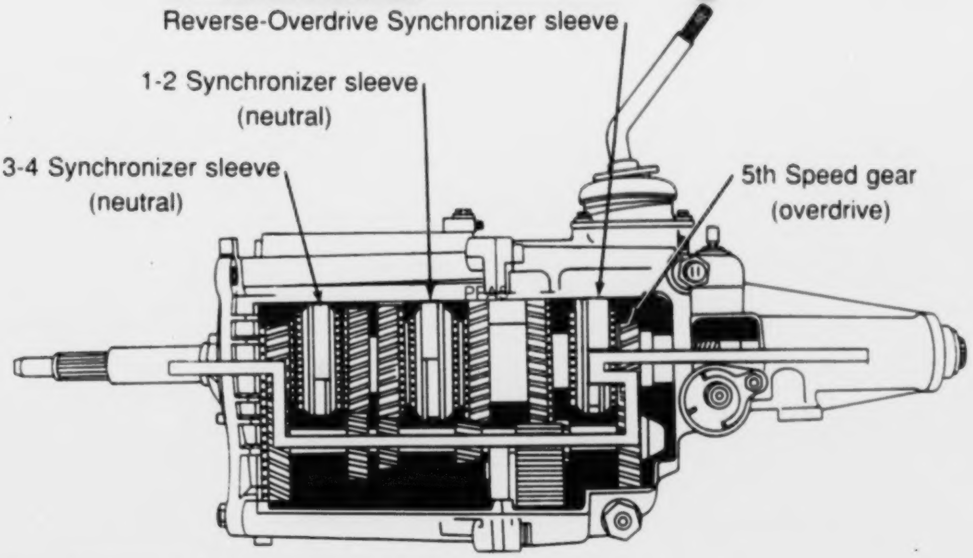
Used with permission of Chrysler Corporation.

Fourth


1-2 Synchronizer sleeve (neutral)
3-4 Synchronizer sleeve
4th Speed gear
(Direct drive)

Used with permission of Chrysler Corporation.

Fifth (Overdrive)


Reverse-Overdrive Synchronizer sleeve
1-2 Synchronizer sleeve (neutral)
3-4 Synchronizer sleeve (neutral)
5th Speed gear (overdrive)

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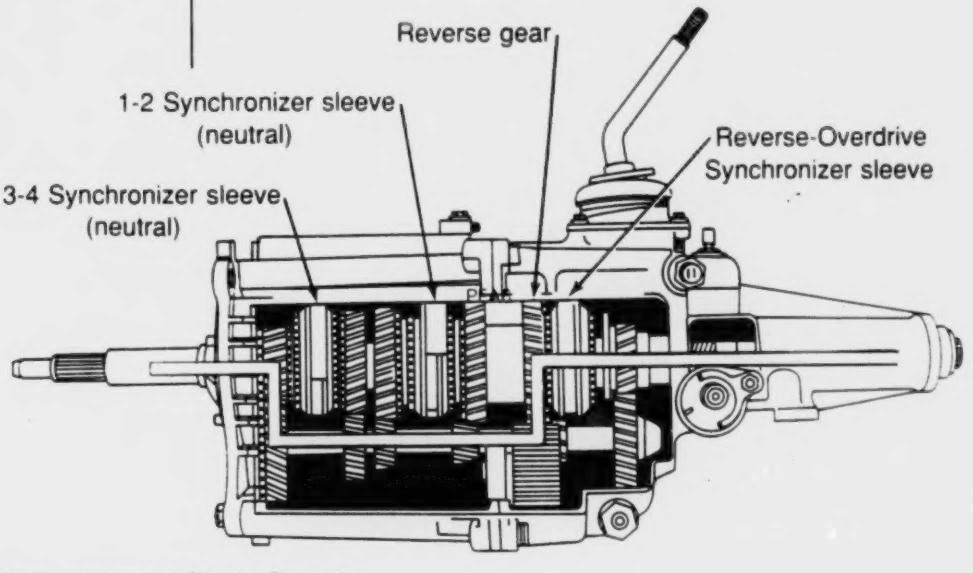
Reverse


Reverse gear
1-2 Synchronizer sleeve (neutral)
Reverse-Overdrive Synchronizer sleeve
3-4 Synchronizer sleeve (neutral)

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OBJECTIVE SHEET

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

INTRODUCTION

A transaxle combines the functions of a transmission and a differential. Usually found in front-engine, front-wheel drive vehicles, transaxles are also used with mid and rear engines and in four-wheel drive vehicles. Although transaxles have been in use for many years, their versatility and increasing popularity has resulted in a wide variety of different transaxle designs. The front drive axles used with a transaxle must transfer torque and respond to the needs of the steering and suspension systems. Constant velocity joints give the axles the high flexibility needed to operate under these conditions.

PREREQUISITE

Before studying this unit, the student must have successfully completed Unit 4, *Service Manual Transmissions*.

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose manual transaxle and front drive axle problems and service and repair these components. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Choose the correct definitions for terms associated with the automotive manual transaxle and front drive axles by selecting the correct definition from four choices.
2. Label the components of a front-wheel power train on an illustration.
3. Label the major sections and parts of a manual transaxle on an illustration.
4. Match the names of the parts of a front drive axle to an illustration.

5. Label four common types of drive axle joints and match the names of their parts to illustrations.

6. Diagnose manual transaxle and front drive axle noise and performance problems. (Assignment Sheet 1)

7. Demonstrate the ability to:

    A. Inspect, adjust, and replace transaxle shift linkage components located outside the transaxle housing. (Job Sheet 1)

    B. Remove and replace front drive axles. (Job Sheet 2)

    C. Inspect, remove, and replace front drive axle boots. (Job Sheet 3)

    D. Remove, inspect, and replace front drive axle joints. (Job Sheet 4)

    E. Inspect, remove, and replace transaxle power train mounts. (Job Sheet 5)

    F. Remove a transaxle assembly. (Job Sheet 6)

    G. Remove, inspect, and replace transaxle shift assembly components located inside the transaxle housing. (Job Sheet 7)

    H. Remove, inspect, and replace input shaft assembly components. (Job Sheet 8)

    I. Remove, inspect, and replace output shaft assembly components. (Job Sheet 9)

    J. Remove, inspect, and replace reverse idler gear assembly components. (Job Sheet 10)

    K. Measure and adjust end play and preload on transaxle shafts. (Job Sheet 11)

    L. Remove, inspect, adjust, and replace the transaxle differential section. (Job Sheet 12)

    M. Remove, inspect, and replace the speedometer drive assembly. (Job Sheet 13)

    N. Clean and inspect the transaxle housing and transaxle housing components. (Job Sheet 14)

    O. Assemble a transaxle. (Job Sheet 15)

    P. Install a transaxle and complete transaxle service. (Job Sheet 16)

PREPARATION

Review unit and plan presentation

- Study the specific objectives to determine the order in which you will present the objectives. Decide whether or not you wish to add additional objectives.
- Review teaching suggestions given in the Delivery section and plan classroom activities.
- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.
- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

Obtain supplemental materials

- Order films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrates job sheet skills. Videotape your own procedures if you are unable to obtain suitable media.
- Copies of current articles on subjects covered in this unit may be obtained by writing to the *Automotive Information Council's* Reference Center. They will also conduct a computer search for such articles. See the note in the section on Media for more information about this free service.
- Obtain competency profiles for this unit.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364, 1-800-522-5810, ext. 589 in-state; 1-800-654-4502 out-of-state.

- Note equipment and materials needed for completing job sheets.

Prepare classroom and shop

- Display safety signs, posters, and charts that show manual transaxles and front drive axle components and service, etc.
- Have magazine articles, specification guides, service manuals, mock-ups, and other references about the manual transaxle and front drive axles available for student use.
- Check tools and equipment against job sheet requirements.

Administer Pretest

- Administer the pretest.
- Use the pretest results to assess student competencies, considering the results as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the Introduction to the unit in the Objective Sheet.
- Discuss the unit objective and then the specific objectives. Point out that many of the tasks covered by the job sheets have already been covered in the units on the transmission and the differential. Discuss the fact that many of the procedures are similar or identical to procedures in those units and that this unit will rely heavily on the material from those guidelines and job sheets.
- Raise a vehicle which has a transaxle and show the students the components covered by this unit.

Objective 1 Choose the correct definitions for terms associated with the automotive manual transaxle and front drive axles by selecting the correct definition from four choices.

- Show examples or demonstrate terms where applicable.

Objective 2 Label the components of a front-wheel power train on an illustration.

- Show the students one or more examples of actual front-wheel power trains.

- Discuss the material in the box, "Front-Wheel Power Train Components."
- Show part 1, "Drive Systems: Components and Assembly," of the video program, *Front Wheel Drive: The Concept, the Fundamentals, the Operation.*
- Review the material in the box, "Advantages of a Front-Wheel Drive Transaxle."
- Discuss the material in the box, "Power Train Designs Using Transaxles," giving examples of specific vehicles which use transaxles but have other than a front-engine, front-wheel drive power train.

Objective 3 Label the major sections and parts of a manual transaxle on an illustration.

- Display an example of a transaxle as you discuss the material in the box on "Transaxles."
- Show examples of special tools that are sometimes required to disassemble and reassemble a transaxle.
- If the transaxle you are using as an example has a clutch assembly which varies significantly from the clutch assemblies used with transmissions, point out the differences in the clutch to the class.
- Show the class the *transmission section* and the *differential section* of the transaxle. Make sure they understand what parts and components are included in each.
- Compare the functions of a transaxle to the functions of a transmission and a differential.
- Discuss the function of the *output shaft drive gear* and the fact that it assumes the function of the drive pinion gear assembly on a differential.
- Show part 1, "Basic Construction and Operation of Front Wheel Drives," of the video program, *Front Wheel Drive Explained.*
- Discuss the material in the box on "Dual-Range Transaxles." Show the students an example of such a transaxle if available.
- Use the boxed material on "Transaxle Design" along with different types of transaxles available in your shop to discuss the wide range of different transaxle designs.

- Draw the students' attention to additional transaxle designs not shown in the text.

  NOTE: The examples illustrated were selected both because they represented a variation in transaxle design and because a relatively clear illustration of the design was readily available.

- Discuss the implications such different designs have for diagnosis and service of a transaxle.

Objective 4 Match the names of the parts of a front drive axle to an illustration.

- Display an example of an actual front drive axle as you discuss the material in the box, "Front Drive Axles."

- Show the students the difference between a *snap ring* and a *circlip*.

- Show the difference between a *stub shaft* and a *spindle shaft* and help the students see differences that will help them identify each if the drive shaft is disassembled.

- Discuss the boxed material on "Eliminating Torque Steer," showing students examples of components used on actual vehicles which illustrate methods of eliminating this problem.

- Discuss the fact that the axle design used for front drive axles is also sometimes used for rear drive axles—particularly when the engine is located in the middle or back of the vehicle. Show students examples of such vehicles if available.

Objective 5 Label four common types of drive axle joints and match the names of their parts to illustrations.

- Show the video, *CV-1 Introduction to CV Joints*.

- Display actual C-V joints of the four common types of drive axle joints discussed and encourage students to handle them as you explain the material in the text.

- Discuss the material in the box, "Front Drive Axle Joints."

- Demonstrate the difference in the movement of a plunging joint and a fixed joint.

- Have the students quiz each other on the parts of the four common types of drive axle joints.

- Show students examples of constant velocity joints other than the four mentioned and review their parts and operation.

APPLICATION

Objective 6 Diagnose manual transaxle and front drive axle noise and performance problems. (Assignment Sheet 1)

- Discuss the material in Supplement 1, "Transaxle and Front Drive Axles Troubleshooting Guide," with the students.
- Show the videos, *C.V. Joints*, and *CV-2 Troubleshooting and Inspection*, and discuss how to diagnose noise and performance problems in C-V joints.
- Show part 2, "Performance Characteristics of Front Wheel Drive and Troubleshooting," of the video program, *Front Wheel Drive: The Concept, the Fundamentals, the Operation*.
- Review the material in Supplements 2, 3, & 4, diagnostic charts for transaxle and front drive axle performance, noise, and leaks. Point out that the possible causes for a condition which are listed first are more probable.
- Use the slides, *Noise, Vibration, and Harshness*, and the video, *NVH Vehicle Diagnosis*, to assist with identifying problem transaxle noises.
- Have the students complete Assignment Sheet 1

Objective 7A Inspect, adjust, and replace transaxle shift linkage components located outside the transaxle housing. (Job Sheet 1)

- Show the students examples of both a two-cable type of shift linkage and a rod and lever linkage. Point out the parts of each and demonstrate how each type of shift linkage works.
- Discuss the boxed material on "Torquing-Over" and show the students examples of struts which help reduce this problem in a transaxle.
- Discuss how the conditions created by torquing-over can affect the technician's difficulty in diagnosing transaxle problems.
- Review the Guidelines in Job Sheets 1 and 2, Unit 4, for adjusting rod and lever and cable type shift linkages with the students. Discuss which guidelines will be useful for completing these procedures on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to inspect, adjust, and replace a shift linkage on a vehicle in your shop.
- Have the students complete Job Sheet 1.

Objective 7B Remove and replace front drive axles. (Job Sheet 2)

- Show the filmstrip, *GM X-Body Front-Drive Axle Service*, part 1, "Front Axle: Removal," and part 5, "Drive Axle Installation."
- Discuss the Guidelines for removing and replacing front drive axles with the students. Demonstrate procedures where applicable.
- Demonstrate the correct way to hold the front drive axle during removal so that the C-V joints do not bend excessively.
- Show the students a boot protector and discuss its purpose during drive axle removal.
- Demonstrate how to make a homemade boot protector.
- Show the students how to remove drive axles which are held in place by flanges, circlips, and C-locks.
- Use an appropriate service manual to demonstrate the procedures necessary to remove and replace the front drive axles on a vehicle in your shop.
- Have the students complete Job Sheet 2.

Objective 7C Inspect, remove, and replace front drive axle boots. (Job Sheet 3)

- Stress the fact that if the boot on the drive axle joint fails, the joint will almost surely fail very quickly.
- Discuss how, when, and how often the front boots should be inspected.
- Display a boot which is damaged by age and demonstrate how to identify such damage.
- Show samples of several types of front drive axle boot kits and discuss the various types and materials.

- Demonstrate how to install a split boot and discuss the material in the box on "Split Boots," pointing out the advantages and disadvantages of such an installation.

- Demonstrate the procedures in the Job Sheet.

- Have the students complete Job Sheet 3.

Objective 7D Remove, inspect, and replace front drive axle joints. (Job Sheet 4)

- Show the filmstrip, *GM X-Body Front-Drive Axle Service*, part 2, "Front Axle: Disassembling the Outer Joint," and part 3, "Front Axle: Assembling the Outer Joint."

- Display samples of damaged C-V joints and instruct students how to identify wear that is severe enough to require that the joint be replaced.

- Show samples of several types of front drive axle joint kits and discuss the various types.

- Use an appropriate service manual as a reference as you demonstrate the procedures in the job sheet.

- Demonstrate how to remove and replace front drive axle C-V joints other than the two types for which procedures are given.

- Have the students complete Job Sheet 4.

Objective 7E Inspect, remove, and replace transaxle power train mounts. (Job Sheet 5)

- Show part 3, "Overhaul and Alignment," of the video, *Front Wheel Drive: The Concept, the Fundamentals, the Operation*.

- Discuss the job sheet Guidelines with the students, demonstrating procedures where applicable.

- Show the students a number of examples of power train mounts on vehicles which have a transaxle.

- Demonstrate the procedure in the Guidelines for aligning the power train mounts if no method is given by the manufacturer.

- Use an appropriate service manual to demonstrate the procedures necessary to inspect, remove and replace transaxle power train mounts on a vehicle in your shop.

♦ WARNING ♦

If the service manual directs that the mounts be tightened while the engine is still running, it is strongly suggested that you discourage your students from following these instructions.

- Have the students complete Job Sheet 5.

Objective 7F Remove a transaxle assembly. (Job Sheet 6)

- Show part 1, "Transaxle Removal Procedures," of the video, *Front Wheel Drive: Transaxle Overhaul.*
- Show part 3, "Power Flow Maintenance and Engine Removal and Replacement," of the video, *Front Wheel Drive Explained.*
- Discuss the job sheet Guidelines with the students, demonstrating procedures where applicable.
- Demonstrate the correct procedures for removing and replacing the hood, stressing the importance of avoiding damage to this large part.
- Show the students how to locate the list of special tools needed for transaxle service in a vehicle service manual.
- Use an appropriate service manual to demonstrate the procedures necessary to remove a transaxle assembly.
- Demonstrate the removal of several types of transaxles.
- Have the students complete Job Sheet 6.

Objective 7G Remove, inspect, and replace transaxle shift assembly components located inside the transaxle housing. (Job Sheet 7)

- Show part 2, "Disassembly of Transaxle," and part 3, "Subassembly Overhaul," of the video program, *Front Wheel Drive: Transaxle Overhaul.*
- Show part 4, "Technical Servicing and Maintenance," of the video program, *Front Wheel Drive: The Concept, the Fundamentals, the Operation.*

- Show the students examples of transaxles which have different types of shift assemblies.

- Review the Guidelines for removing, inspecting, and replacing transmission internal shift components found in Job Sheet 5, Unit 4. Discuss which guidelines will be useful for completing these procedures on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to remove, inspect, and replace a transaxle shift assembly.

- Have the students complete Job Sheet 7.

Objective 7H Remove, inspect, and replace input shaft assembly components. (Job Sheet 8)

- Display input shaft assemblies from several different transaxles.

- Have the students identify the parts on an input shaft.

- Compare the input shaft from a transaxle and one from a transmission.

- Review the Guidelines for removing, inspecting, and replacing input shafts, output shafts, and synchronizers found in Job Sheets 6, 7, and 8, Unit 4. Discuss which guidelines will be useful for completing these procedures on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to remove, inspect, and replace input shaft assembly components.

- Have the students complete Job Sheet 8.

Objective 7I Remove, inspect, and replace output shaft assembly components. (Job Sheet 9)

- Display output shaft assemblies from several different transaxles.

- Have the students identify the parts on an output shaft.

- Compare the output shaft from a transaxle and one from a transmission.

- Review the Guidelines for removing, inspecting, and replacing input shafts, output shafts, and synchronizers found in Job Sheets 6, 7, and 8, Unit 4. Discuss which guidelines will be useful for completing these procedures on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to remove, inspect, and replace output shaft assembly components.

- Have the students complete Job Sheet 9.

Objective 7J Remove, inspect, and replace reverse idler gear assembly components. (Job Sheet 10)

- Show the students reverse idler gear assemblies from several different transaxles.

- Review the Guidelines from Job Sheet 10, Unit 4, for removing, inspecting, and replacing reverse idler gear assemblies on a transmission. Discuss which guidelines will be useful for completing these procedures on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to remove, inspect, and replace reverse idler gear assembly components.

- Have the students complete Job Sheet 10.

Objective 7K Measure and adjust end play and preload on transaxle shafts. (Job Sheet 11)

- Review the meaning of the terms *end play* and *preload* and the way they were measured and adjusted on a transmission and differential.

- Have the students use appropriate service manuals to research and give oral reports on the ways end play and preload are measured and adjusted on several different transaxles. Have them report on:

    — How and when end play is measured, and how it is adjusted
    — How and when preload is measured, and how it is adjusted

- Use an appropriate service manual to demonstrate the procedures necessary to measure and adjust end play and preload on one of the transaxles in the shop.

- Have the students complete Job Sheet 11.

Objective 7L Remove, inspect, adjust, and replace the transaxle differential section. (Job Sheet 12)

- Review the job sheet procedures in Unit 2, *Service Differentials*, which must be performed in order to complete this job sheet.
- Demonstrate methods of measuring and adjusting ring to output shaft drive gear backlash on a transaxle.
- Use an appropriate service manual and the applicable job sheets from Unit 2 to demonstrate the procedures necessary to remove, inspect, adjust, and replace the transaxle differential section.
- Have the students complete Job Sheet 12.

Objective 7M Remove, inspect, and replace the speedometer drive assembly. (Job Sheet 13)

- Show the students examples of the three main types of speedometer drive assemblies used on transaxles. Explain how each works.
- Display vehicles which illustrate the different locations where these assemblies can be installed.
- Use an appropriate service manual to demonstrate the procedures necessary to remove, inspect, and replace a speedometer drive assembly on a vehicle in your shop.
- Demonstrate these procedures on vehicles which have different types of speedometer drive assemblies and/or which are installed in other locations on a vehicle.
- Have the students complete Job Sheet 13.

Objective 7N Clean and inspect the transaxle housing and transaxle housing components. (Job Sheet 14)

- Examine a transaxle housing and discuss any special cleaning and inspection requirements it may have.
- Compare a transaxle housing and a transmission housing and point out differences between the two.

- Review the Guidelines for cleaning and inspecting the transmission housing from Job Sheet 12, Unit 4. Discuss which guidelines will be useful for completing these procedures on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to clean and inspect a transaxle housing.

- Have the students complete Job Sheet 14.

Objective 7O Assemble a transaxle. (Job Sheet 15)

- Show part 4, "Reassembly of Transaxle," of the video program, *Front Wheel Drive: Transaxle Overhaul.*

- Review the Guidelines for assembling a transmission from Job Sheet 13, Unit 4. Discuss which guidelines will be useful for completing this procedure on a transaxle.

- Use an appropriate service manual to demonstrate the procedures necessary to assemble a transaxle in your shop.

- Have the students complete Job Sheet 15.

Objective 7P Install a transaxle and complete transaxle service. (Job Sheet 16)

- Show the students types of transaxle lubricant and discuss their different qualities.

- Demonstrate ways that transaxle lubricant is measured, showing examples of different methods on available vehicles.

- Have students use different service manuals to research:

  — How often the transaxle lubricant should be changed
  — The amount of lubricant recommended
  — The type of lubricant recommended

- Have each student report on his/her findings and compile a composite profile of the class's results.

- Show part 5, "Transaxle Replacement," of the video program, *Front Wheel Drive: Transaxle Overhaul.*

- Show part 3, "Power Flow Maintenance and Engine Removal and Replacement," from the video program, *Front Wheel Drive Explained*, to review the procedures necessary for engine replacement as a part of transaxle installation.

- Review the Guidelines for completing transmission service from Job Sheet 13, Unit 4. Discuss which guidelines will be useful for completing this procedure on a transaxle.
- Use an appropriate service manual to demonstrate the procedures necessary to assemble a transaxle.
- Demonstrate the replacement of several types of transaxles.
- Have the students complete Job Sheet 16.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate class members on assignment sheet activities if not previously done. Provide them with copies of Supplement 1, "Transaxle and Front Drive Axles Troubleshooting Guide," Supplement 2, "Transaxle and Front Drive Axles Performance Diagnosis Chart," Supplement 3, "Transaxle and Front Drive Axles Noise Diagnosis Chart," and Supplement 4, "Transaxle and Front Drive Axles Leak Diagnosis Chart." The students will also need Supplements 1-4, Unit 3, to help evaluate the possibility of transaxle problems that are clutch-related.
- Give the practical tests. Evaluate the tests on forms provided.
- Reteach and retest as required
- Complete the appropriate section of the competency profiles.
- Review individual and group performance in order to evaluate teaching methods.
- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- Abbott, Sheldon L. *Automotive Power Trains*, 2nd ed. Encino, California: Glencoe Publishing Co., 1988.
- *Car 1987 Shop Manual—Powertrain, Lubrication, Maintenance*. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.
- *Chilton's Auto Repair Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.

- *Chilton's Import Car Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill, 1985.
- Crouse, William H., and Donald L. Anglin. *Manual Transmissions and Power Trains*, 6th ed. New York: Gregg Division, McGraw-Hill, 1983.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- Erjavec, Jack. *Manual Transmissions and Transaxles*. New York City, New York: Harcourt Brace Jovanovich, Technology Publications, 1990.
- *5-Speed Manual Transaxle*. Detroit, Michigan: General Motors Co., 1982.
- Hughes, James G. *Guide to Automobile Certification Examination*, revised ed. Reston, Virginia: Reston Publishing Co., Inc., a Prentice-Hall company, 1983.
- *Introduction to Automotive Service*. Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1989.
- Kovacik, Robert T., and Clifford Creager. *Manual Transmissions and Drivetrains*. Cincinnati, Ohio: South-Western Publishing Co., 1984.
- *Manual 5-Speed Transaxle*. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1982.
- *Manual Transaxle*. Detroit, Michigan: General Motors Corporation, 1978.
- *Manual Transaxle-Domestic-Student Reference Guide*. Center Line, Michigan: Chrysler Motors, Training Program Development Department, 1987.

- *Manual Transaxle Operation and Diagnosis*. Detroit, Michigan: Ford Parts and Service Division, Training and Publications Department, 1980.
- Mitchell Information Services, Inc. *Mitchell Automechanics*. Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- *Muncie 5-Speed Manual Transaxle*. Detroit, Michigan: General Motors Co., 1988.
- *Official ASE Preparation Guide to ASE Automobile Tests, The*. Reston, Virginia: National Institute for Automotive Service Excellence, 1989.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1982.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.
- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1983.
- Webster, Jay. *Auto Mechanics*, 2nd ed. Encino, California: Glencoe Publishing Co., Inc., 1986.
- Webster, Jay. *Automotive Power Train Systems*. Homewood, Illinois: American Technical Publishers, Inc., 1982.
- White, John H. *Manual Transmissions and Drivetrains*. Albany, New York: Delmar Publishers Inc., 1987.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Automotive Information Council—Reference Center.* 13505 Dulles Technology Drive, Herndon, Virginia 22071-3415, phone (703) 904-0700. The AIC Reference Center has a reference base of over 10,000 volumes, maintaining subscriptions to over 100 trade and consumer publications relating to the automotive industry. Their computer indexing system can provide educators with up-to-date print-outs of books, articles from periodicals, statistical abstracts, press releases, catalogues, and other reference materials on 90 automotive subject classifications. AIC's services are free of charge. Copies of current articles from periodicals are also available free if requested in nominal quantities.

- *C.V. Joints.* 20 minutes, video. Moog. Automotive Service Association, P.O. Box 1047, Bedford, Texas 76095-1047, phone (817) 283-6205. Describes diagnosing and replacing CV joints.

- *CV-1 Introduction to CV Joints.* 14 minutes, video. Perfect Circle. Automotive Service Association, P.O. Box 1047, Bedford, Texas 76095-1047, phone (817) 283-6205. Includes a brief history, an overview of the various types of CV joints and the theories behind their operation, and a discussion of the specific CV joint service programs available.

- *CV-2 Troubleshooting and Inspection of CV Joints.* 8 minutes, video. Perfect Circle. Automotive Service Association, P.O. Box 1047, Bedford, Texas 76095-1047, phone (817) 283-6205. Three basic areas of troubleshooting and inspection: road test, visual inspection, and wheel spin test.

- *Front Wheel Drive: The Concept, the Fundamentals, the Operation.* 4 part video, 40 minutes. Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050, phone 1-800-431-1242. Drive Systems: Components and Assembly; Performance Characteristics of Front Wheel Drive and Troubleshooting; Overhaul and Alignment; Technical Servicing and Maintenance.

- *Front Wheel Drive Explained.* 3 part video, 42 minutes. Bergwall Productions, Inc. P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565. Basic Construction and Operation of Front Wheel Drives; Front Suspension Overhaul and Alignment; Power Flow Maintenance and Engine Removal and Replacement.

- *Front Wheel Drive: Transaxle Overhaul.* 5 part video, 56 minutes. Bergwall Productions, Inc. P.O. Box 238, Garden City, New York 11530-0238, phone 1-800-645-3565. Transaxle Removal Procedures; Disassembly of Transaxle; Subassembly Overhaul; Reassembly of Transaxle; Transaxle Replacement Procedures.

- *GM X-Body Front-Drive Axle Service.* 5 parts, filmstrips. Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050, phone 1-800-431-1242. Front Axle: Removal; Front Axle: Disassembling the Outer Joint; Front Axle: Assembling the Outer Joint; Removing and Replacing the Front-Wheel Bearing; Drive Axle Installation.

- *Noise, Vibration and Harshness.* 50 color slides, 58 p. Instructor Guide, and 46 p. Student Text. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. The object of this text is to improve mechanical skills, to increase the accuracy of diagnosis and to provide time-saving procedures for the identification and elimination of problems relating to vehicle noise, vibration and harshness.

- *NVH Vehicle Diagnosis.* 26 minutes, color video. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356. Defines noise, vibration, and harshness concerns; provides diagnostic theory and repair procedures in step-by-step format.

PRETEST ANSWERS

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions:

Objective	Question
1	1, 2
2	3
3	4
4	5
5	6
6	7, 8
7A	9
7B	10
7C	11
7D	12
7E	13
7F	14
7G	15
7H	16
7I	17
7J	18
7K	19
7L	20
7M	21
7N	22
7O	23
7P	24

ANSWER KEY

1. D
2. B
3. C
4. B
5. C
6. A
7. B
8. C
9. A
10. C
11. A
12. A
13. C
14. C
15. C
16. C
17. B
18. A
19. D
20. A
21. C
22. D
23. B
24. A

PRETEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

NAME ______________________________ SCORE ______

DIRECTIONS

Read the following questions and problems. Then put the letter of the item that best answers the question or solves the problem in the blank.

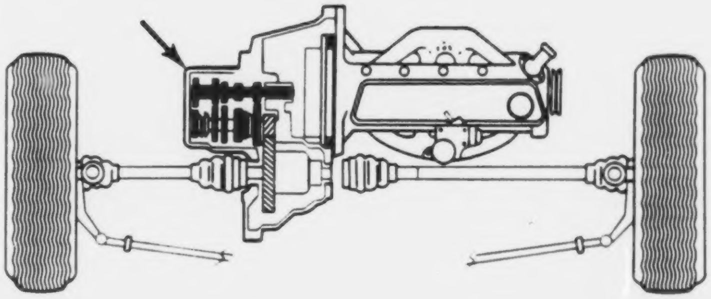
______1. A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle is the:

A. Link shaft
B. Spindle shaft
C. Intermediate shaft
D. Stub shaft

______2. A condition in which a front-wheel drive vehicle with half shafts of unequal length pulls to the side of the longer shaft during acceleration and the side of the shorter shaft during deceleration is called:

A. Torquing-over
B. Torque steer
C. Gear rollover
D. Drive axle pull

______3. The part of a front-wheel power train indicated in the following illustration is the:



Used with permission of Ford Motor Company.

A. Engine
B. Clutch
C. Transaxle
D. Drive axle

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______4. Which of the following transfers the engine's torque directly to the differential ring gear in a transaxle?

A. Input shaft assembly
B. Output shaft assembly
C. Differential side gear
D. Countershaft assembly

______5. The drive axle's stub shaft connects the drive axle to what other part?

A. Wheel hub
B. Steering knuckle
C. Transaxle
D. Output shaft drive gear

______6. Which of the following constant velocity joints is the most common type used on front drive axles?

A. Rzeppa joint
B. Double offset joint
C. Tripod joint
D. Cross groove joint

______7. A transaxle is making a whining noise only during a turn. Technican A says it could be a bad input shaft bearing. Technican B says it is probably worn or damaged gears in the transaxle's differential section. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

______8. A transaxle will not shift into one certain gear. What is the most likely cause?

A. Bad transaxle mount
B. Excessive shaft end play
C. Problem with the shift linkage
D. Damaged tripod joint

______9. **Most** transaxle shift linkages are a(n):

A. Two cable type
B. Rod and lever type
C. Hydraulic type
D. Internal shift linkage

_____10. The front drive axles are removed from the vehicle and there is a special tool extending from the transaxle case where the drive axle should be installed. What is its purpose?

A. To assist in replacing the drive axles
B. To support the inboard C-V joint while the outboard joint is being removed
C. To keep the gears in the differential case in place
D. To measure the transaxle torque

_____11. What is the most common cause of a failed C-V joint?

A. Torn boot
B. Incorrect drive axle angle
C. Damaged transaxle
D. Normal wear

_____12. A vehicle's inboard C-V joint needs to be replaced. Technican A says the drive axle will have to be removed to replace the drive axle C-V joint. Technican B says the joint can be replaced without removing the drive axle. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

_____13. During the visual inspection of a transaxle, the technician is seen pushing up and pulling down on the transaxle. What is he doing?

A. Checking the drive axle angle
B. Checking to see if the vehicle's suspension system is rubbing against the transaxle
C. Checking the transaxle mounts
D. Checking to see if the engine to transaxle bolts are tight

_____14. Technican A says that transaxles are removed through the top of the engine compartment. Technican B says that they are removed from underneath the vehicle. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

_____15. Technican A says that a transaxle's shift forks operate on shift rails inside the transaxle housing. Technican B says that a transaxle shift linkage uses cables or rods and levers to convey shift commands from inside the vehicle to the transaxle. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

_____16. End play on shafts in the transaxle's transmission section should be checked:

A. Before removing the shaft from the housing
B. When replacing the shaft in the housing
C. Both A and B
D. Neither A nor B

_____17. The transaxle output shaft drive gear's function is most similar to a(n):

A. Input gear in a transmission
B. Drive pinion gear in a differential
C. Speed gear in a transmission
D. Engine crankshaft

_____18. The reverse idler gear in a transaxle is usually a:

A. Sliding gear
B. Helical gear
C. Hypoid gear
D. Worm gear

_____19. Preload in a transaxle is measured:

A. On the input shaft
B. On the output shaft
C. On the differential side bearings
D. All of the above

_____20. When replacing the differential section of a transaxle after it has been disassembled, Technican A says you should always make a ring gear tooth contact pattern test. Technican B says it is not necessary to make this test on a transaxle. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

_____21. What type of speedometer drive assembly is becoming most commonly used today?

A. PM generator
B. Traditional gear assembly
C. Electronic speed sensor
D. Worm gear

_____22. A magnet is commonly used as part of a transaxle housing. What is its function?

A. To hold small parts of the shift assembly in place
B. To adjust shaft end play
C. To secure locking washers on the transaxle shafts
D. To attract and hold small pieces of metal in the transaxle lubricant

_____23. When assembling an aluminum transaxle housing, the specialist should take special care to:

A. Use cork or rubber gaskets instead of a liquid sealant
B. Use flat washers under the nuts, bolts, and studs
C. Install the input shaft before the output shaft
D. Install the housing bolts as tight as possible

______24. The most common difference between the lubricant in a transaxle and the lubricant in a transmission is:

A. Transaxle lubricant is usually lighter weight
B. More lubricant is used in the average transmission
C. There are many more types of transaxle lubricant
D. Transaxle lubricant is also used to lubricate the drive axles

OBJECTIVE 1

Choose the correct definitions for terms associated with the manual transaxle and front drive axles by selecting the correct definition from four choices.

boot — A flexible cover used to protect a part

circlip — A snap ring with rounded edges which fits into a groove on a shaft and holds a part which is installed directly over it on the shaft

dual-range transaxle — A type of transaxle which allows twice the usual number of gear ratios

half shaft — The main shaft of a transaxle's drive axle

inboard (in a vehicle) — In a position closest to the midline of the vehicle

NOTE: A *midline* is an imaginary line through the center of the vehicle drawn from front to back.

intermediate shaft — Any transaxle gear shaft in addition to the input shaft, output shaft, and reverse idler gear shaft

link shaft — An additional drive axle shaft used between two half shafts of the same length

outboard (in a vehicle) — In a position farthest from the midline of the vehicle

output shaft drive gear — The gear on a transaxle output shaft which meshes with the ring gear in the transaxle differential section

spindle shaft — A short, splined shaft in a transaxle's drive axle which connects the outboard C-V joint to the wheel hub

stub shaft — A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle

torque steer — A condition in which a front-wheel drive vehicle with half shafts of unequal length pulls to the side of the longer shaft during acceleration and the side of the shorter shaft during deceleration

torquing-over — The tendency of an engine to twist slightly in the direction opposite to the crankshaft rotation when it speeds up

OBJECTIVE 2 **Label the components of a front-wheel power train on an illustration.**

FIGURE 1

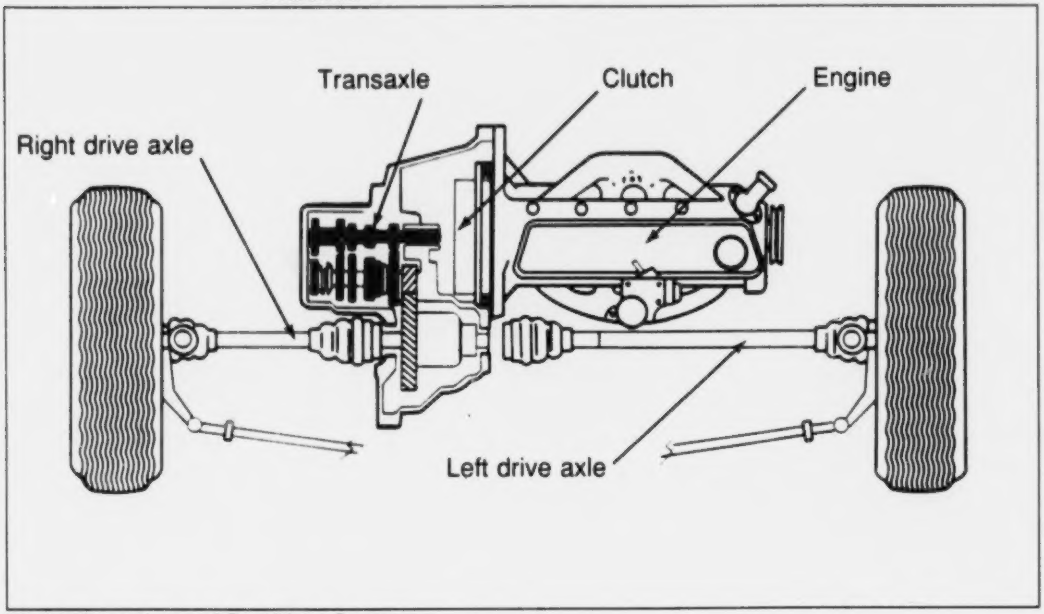
Transaxle
Clutch
Engine
Right drive axle
Left drive axle

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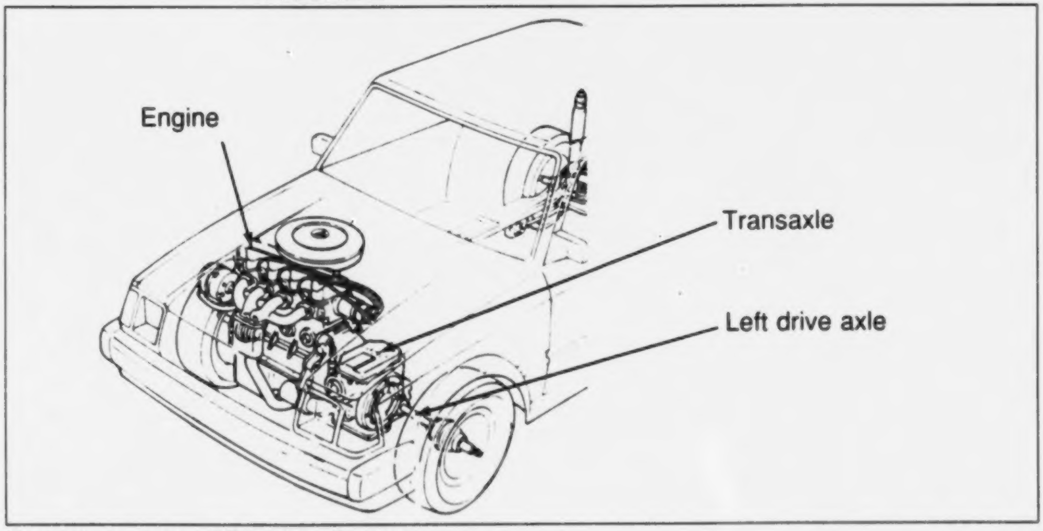
FIGURE 2


Engine
Transaxle
Left drive axle

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FRONT-WHEEL POWER TRAIN COMPONENTS

The power train components in a front-wheel drive vehicle operate much the same as those in a front-engine, rear-wheel drive vehicle, but there can be a number of differences. With the increasing popularity of front-wheel drive vehicles, new design features are constantly being developed by automotive engineers.

Engine — The engine in most front-wheel drive vehicles is installed in a transverse position with its cylinders in line with the drive axles. In about one-half of the front-wheel drive vehicles, the engine must be removed in order to overhaul the clutch and/or transaxle.

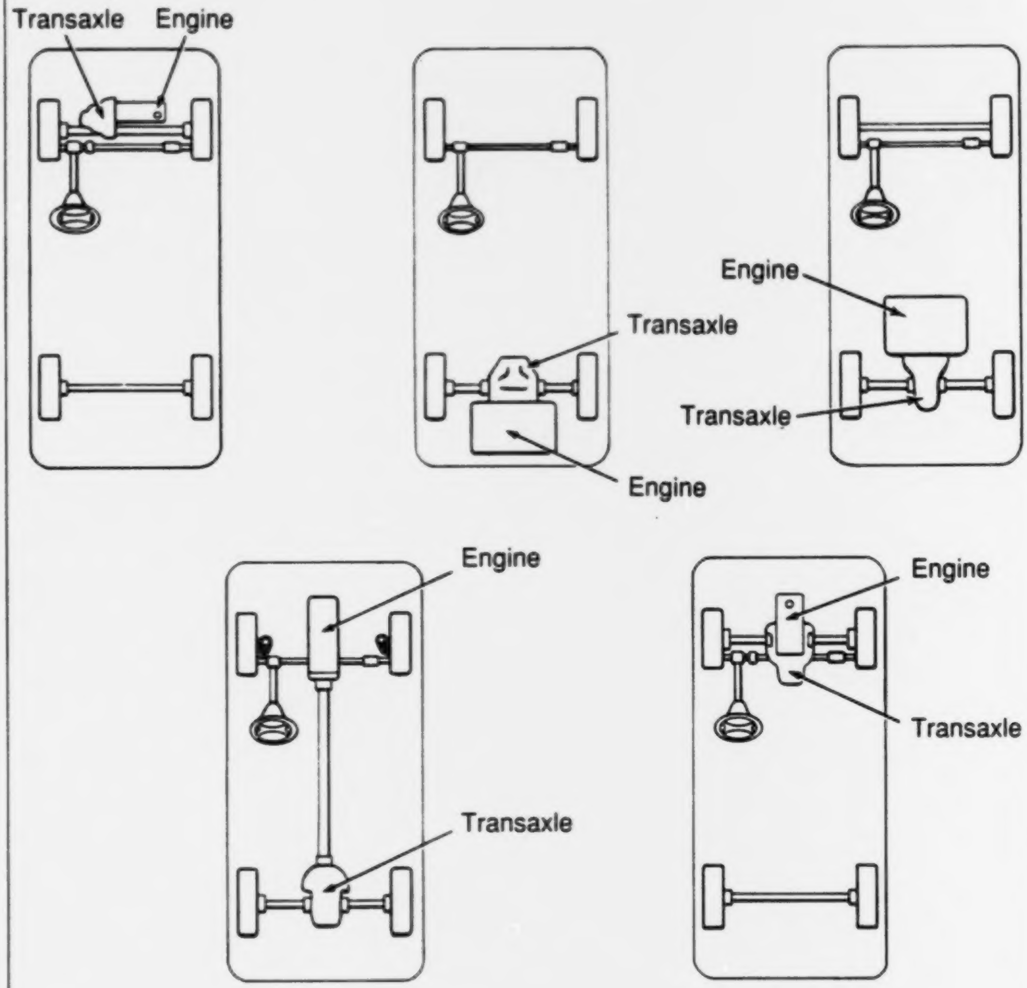
Clutch — Clutches on some front-wheel drive vehicles are connected to a shaft extending from the engine crankshaft rather than to a flywheel. Rod and lever type clutch linkages are not found on front-wheel drive vehicles. The position of the release mechanism and other design features may also be different.

Transaxle — A transaxle is a unit that combines the functions of the transmission and the differential. Since no driveline is needed on a front-wheel drive vehicle, a transaxle is both lighter and more compact than the rear-wheel drive components it replaces.

Drive Axles — In addition to transmitting torque, front drive axles must also adapt to the needs of both the suspension and the steering assemblies. Usually made of solid steel shafts with constant velocity universal joints at both ends, front drive axles are never enclosed in a housing like the drive axles on a rear-wheel drive vehicle.

POWER TRAIN DESIGNS USING TRANSAXLES

Front-wheel power trains are made possible by the use of a ***transaxle***, a transmission and differential combined in one unit. Although about three-fourths of the vehicles using transaxles use them in front-wheel power trains, transaxles are also used in other power train designs.


Transaxle
Engine
Transaxle
Engine
Engine
Transaxle
Engine
Transaxle
Engine
Transaxle

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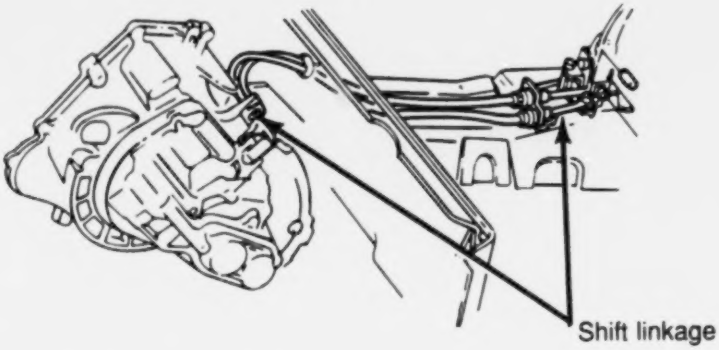
ADVANTAGES OF A FRONT-WHEEL DRIVE TRANSAXLE

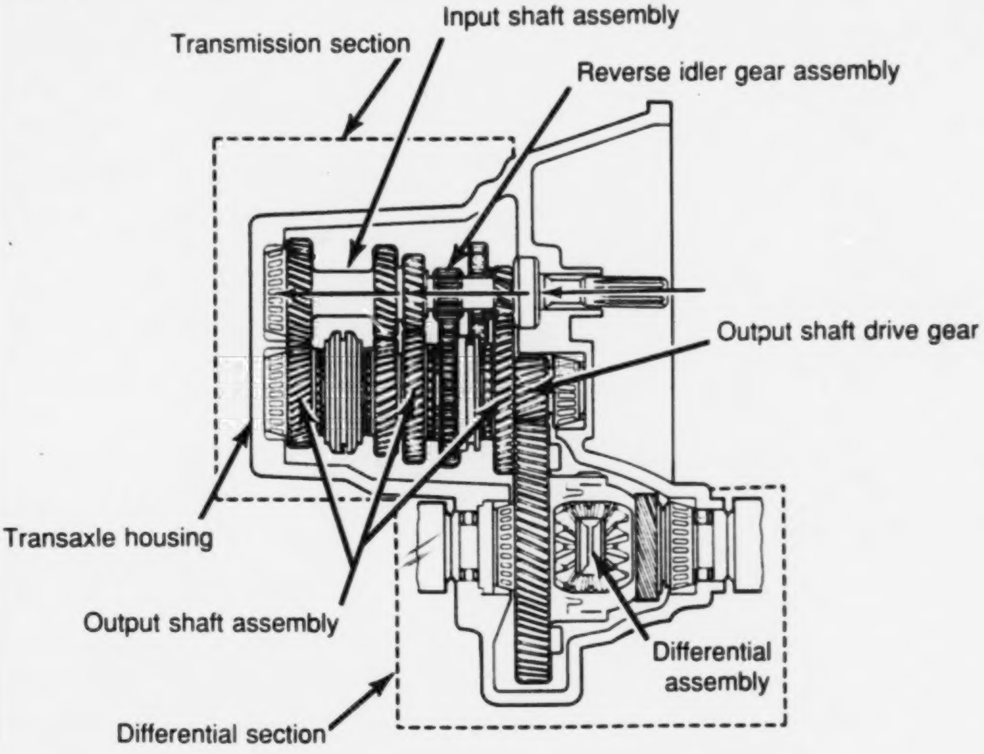
- Greater fuel economy
- Lower vehicle weight
- Increased passenger room
- Better traction
- More responsive steering
- Fewer alignment problems

OBJECTIVE 3 **Label the major sections and parts of a manual transaxle on an illustration.**

FIGURE 3


Shift linkage

Copyright © General Motors Corporation. Used with permission.


Input shaft assembly
Transmission section
Reverse idler gear assembly
Output shaft drive gear
Transaxle housing
Output shaft assembly
Differential assembly
Differential section

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TRANSAXLES

The parts and operation of the transmission section and differential section of a transaxle are almost identical to the parts and operation of a separate transmission and differential. The transaxle shown is common but by no means standard; there is no standard transaxle design.

Gear Shafts — One of the advantages of a transaxle is its compact use of space. Several common design features help save space: there is no countershaft; speed gears are usually narrower; speed gears and synchronizers are often found on both the input shaft and the output shaft, reducing the length of each shaft; reverse gear is almost always a sliding gear. The ***input shaft*** on a transaxle is sometimes called the ***mainshaft***; the ***output shaft*** is sometimes called the ***pinion shaft***. On some transaxles speed gears are installed on additional gear shafts (called ***intermediate shafts***) to decrease overall transaxle length. Because of its extremely compact design, special tools are usually needed to disassemble and reassemble a transaxle.

Gear Ratios — There is no speed gear on a transaxle that gives a direct 1:1 gear ratio. Because of this, transaxles are said to have ***all-indirect gearing***. Sometimes more than one gear on a transaxle is an overdrive gear.

Differential Section — The differential section of a transaxle is very similar to an ordinary differential, but there is no drive pinion gear assembly. An ***output shaft drive gear*** (sometimes called a ***pinion gear*** or a ***transfer gear***) on the transmission section's output shaft meshes directly with the differential ring gear. The output shaft drive gear in a transaxle serves the same function as the drive pinion gear in a differential. Notice that the ring gear is a helical gear rather than the hypoid gear used in a rear-wheel drive differential. Limited-slip differentials are almost never found in transaxles.

Shift Linkage — The ***remote shift linkage*** on a transaxle is a combination of the internal and the external types of shift linkage found on a transmission. The shift forks move inside the housing on shift rails in the manner of an internal shift linkage, but the part of the linkage between the gear shift lever and the transaxle housing is located outside the housing like an external type shift linkage. Most transaxles use two cables to control the movement of the shift shaft. A **selector cable** chooses the desired shift fork and the **shifter cable** causes the desired gear to be engaged. Other remote shift linkages use an assembly of rods and pivots for this part of the shift linkage.

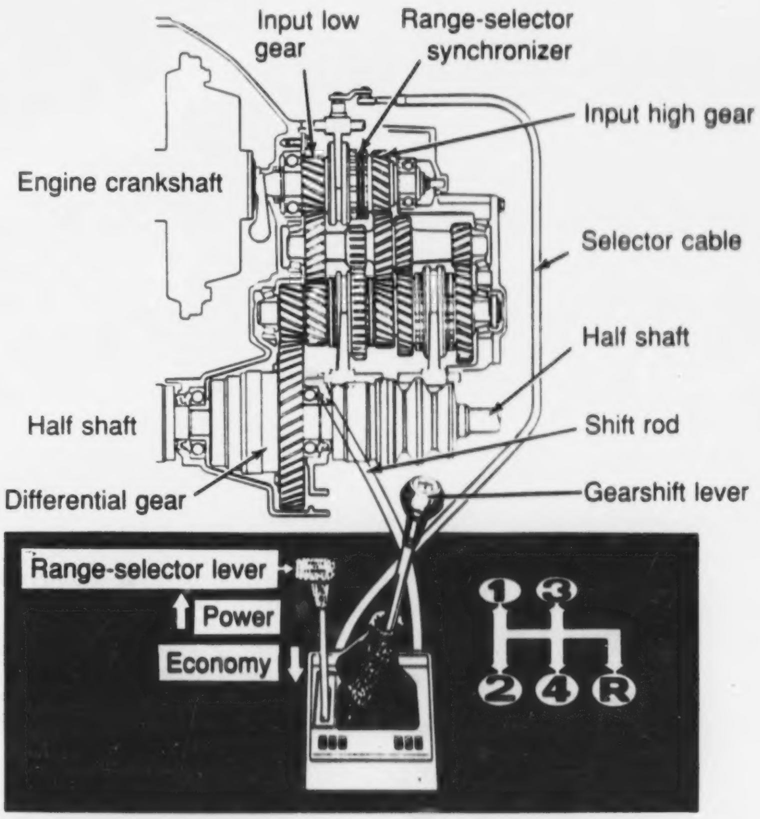
Transaxle Housing — Transaxle housings are made of aluminum to save weight and increase fuel economy. The way the transaxle housing, clutch housing and engine block fit together is extremely variable from model to model. The transaxle may have one or more access covers to allow for inspection or disassembly.

DUAL-RANGE TRANSAXLES

A few transaxles, called ***dual-range transaxles***, are constructed to allow the driver double the normal amount of gear ratio selections. This is achieved by moving the gears (and synchronizers, if equipped) normally found on the input shaft to an intermediate shaft. Two different size input gears and a synchronizer are located on the input shaft. By shifting a separate control lever inside the vehicle, the driver moves the synchronizer from one input gear to another. Because the two input gears are different sizes, the gear ratio that is passed to all the other gears can be changed. The following chart shows typical gear ratios for a dual-range transaxle.

Gear Ratios on a Dual-Range Transaxle

Gear	Power Range	Economy Range
1st	4.226	3.272
2nd	2.365	1.831
3rd	1.467	1.136
4th	1.105	0.855
Reverse	4.109	3.181


Input low gear
Range-selector synchronizer
Input high gear
Engine crankshaft
Selector cable
Half shaft
Half shaft
Shift rod
Differential gear
Gearshift lever
Range-selector lever
Power
Economy
1
3
2
4
R

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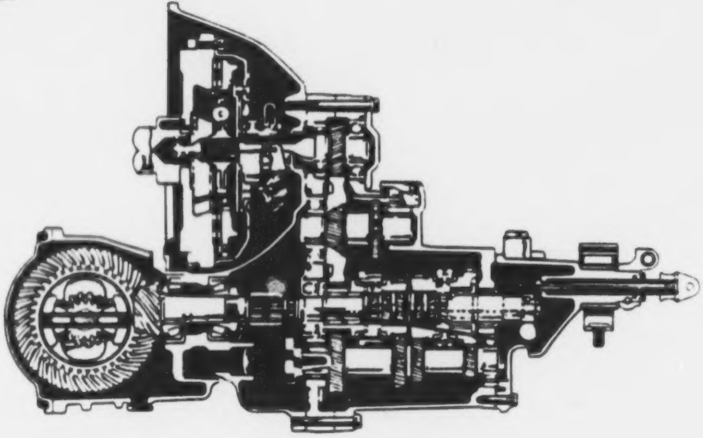
TRANSAXLE DESIGN

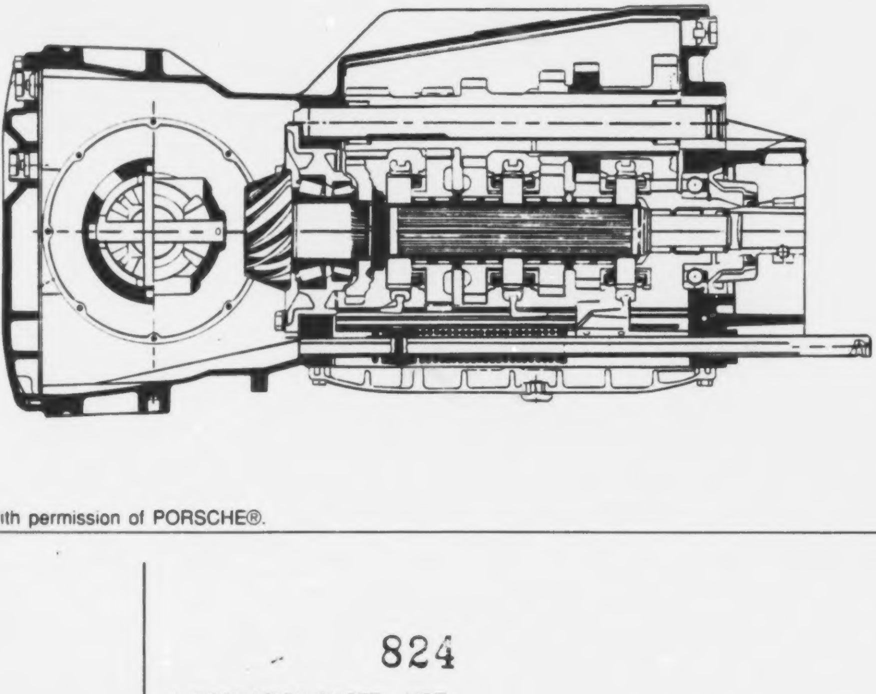
Transaxles are very adaptable. Not only do they save weight and space, but they can be installed in different parts of the vehicle. This adaptability is good news for automotive engineers but bad news for auto service technicians. One of the most difficult things about overhauling a transaxle is that there are so many different transaxle designs. The following are some of the designs that are currently available:

Toyota Tercel



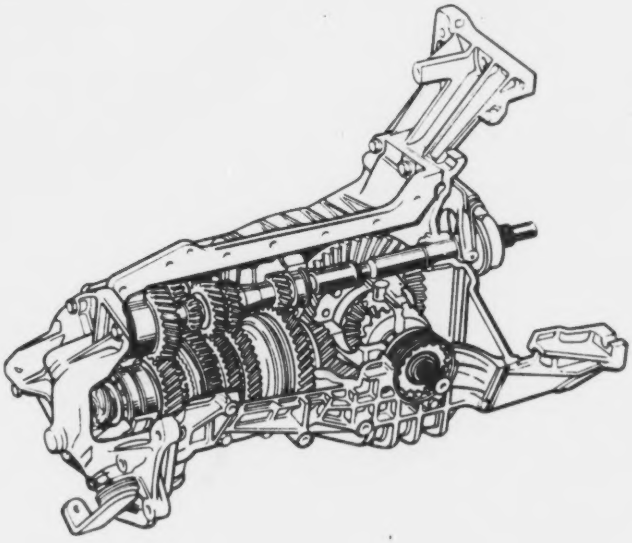
Used with permission of Toyota Motor Sales, U.S.A.

Porsche 928S



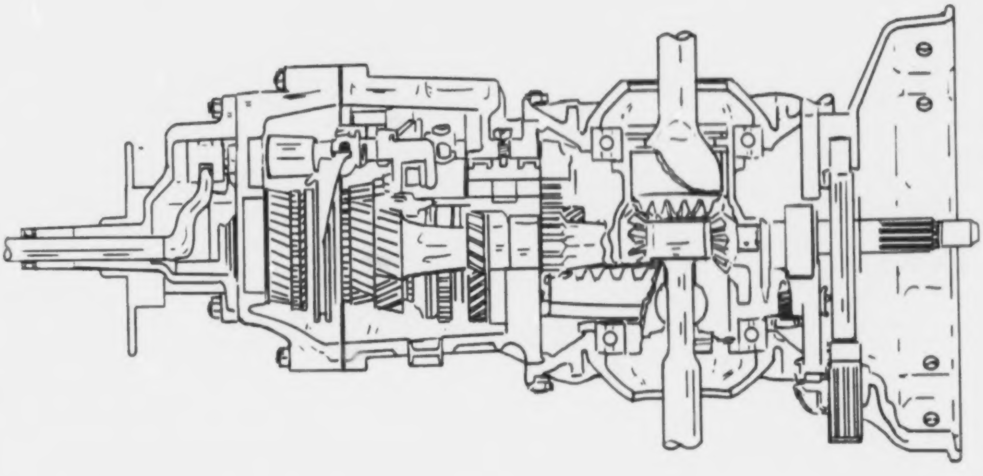
Used with permission of PORSCHE®.

Renault 18i



Used with permission of Chrysler Corporation.

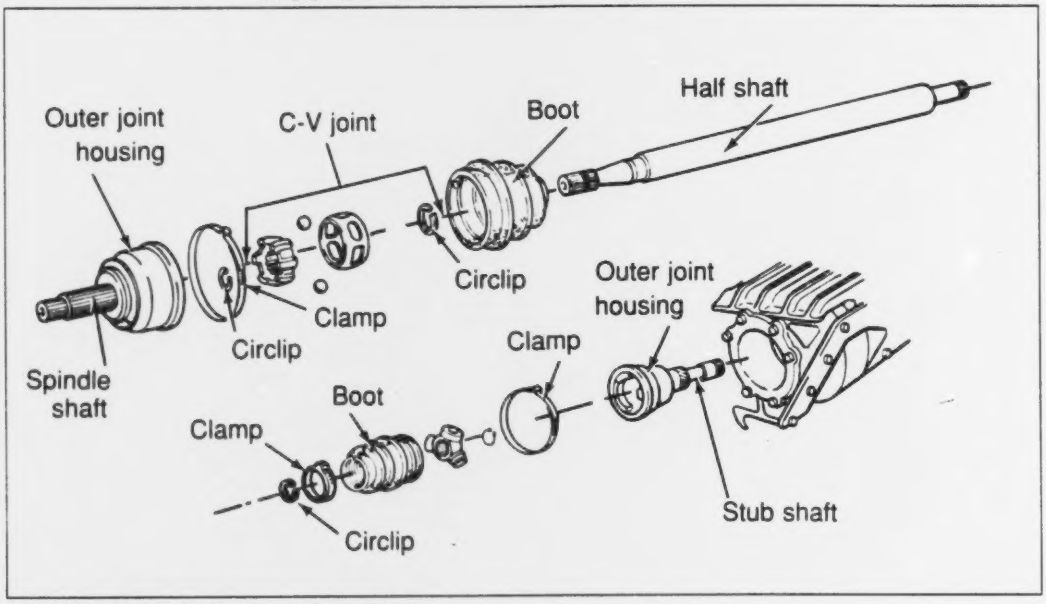
Volkswagen



Adapted with permission of Volkswagen of America.

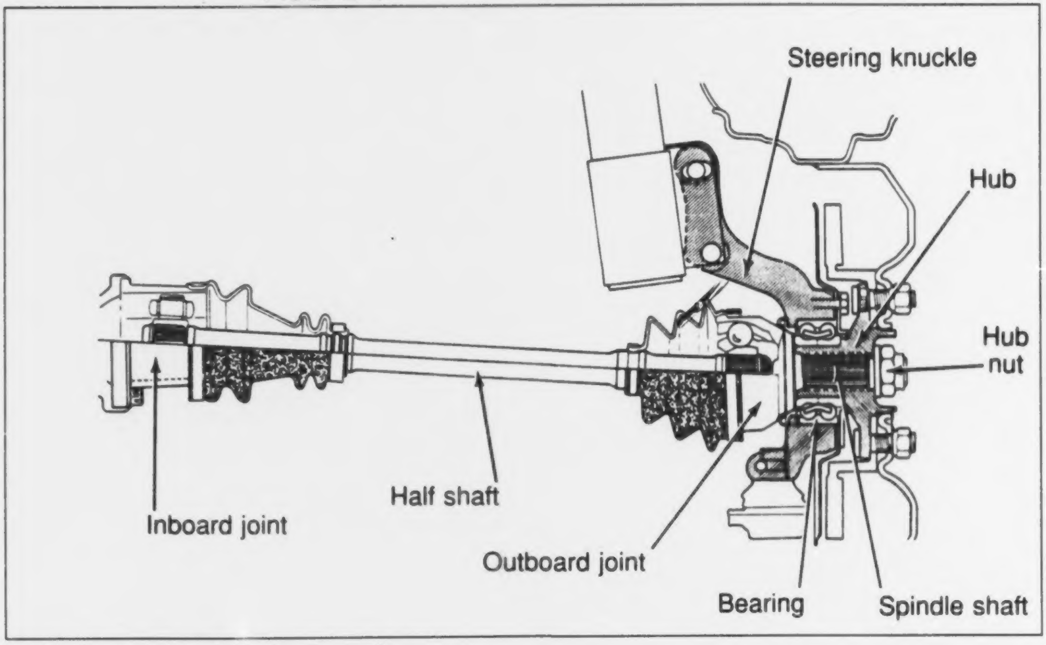
OBJECTIVE 4 **Match the names of the parts of a front drive axle to an illustration.**

FIGURE 4


Half shaft
Outer joint housing
C-V joint
Boot
Circlip
Outer joint housing
Clamp
Circlip
Clamp
Spindle shaft
Boot
Clamp
Stub shaft
Circlip

Used with permission of Chrysler Corporation.

FIGURE 5


Steering knuckle
Hub
Hub nut
Half shaft
Inboard joint
Outboard joint
Bearing
Spindle shaft

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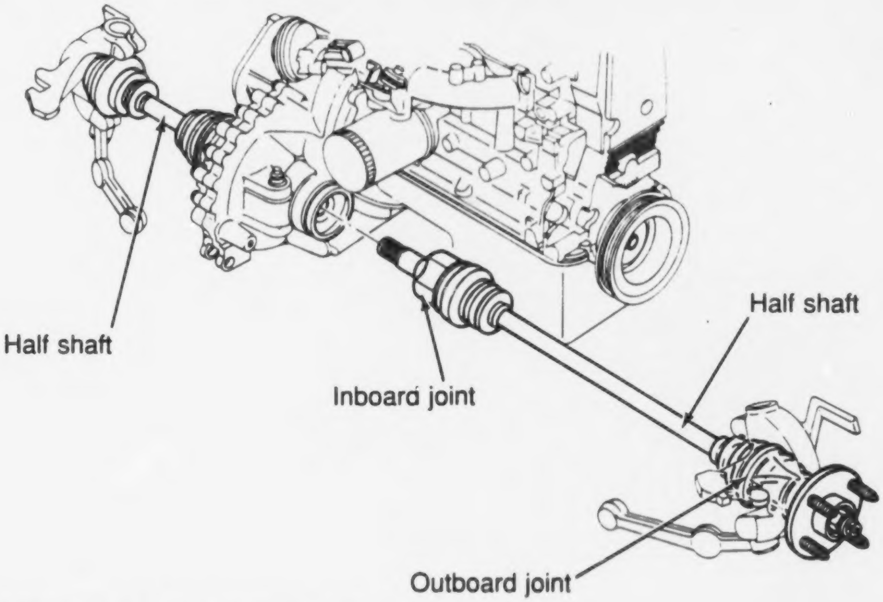
FRONT DRIVE AXLES

Each front drive axle is usually composed of a ***half shaft*** with a ***constant velocity (C-V) joint*** on either end. A short, splined ***stub shaft***, constructed as part of the inboard C-V joint, connects the inboard C-V joint with the transaxle. A ***spindle shaft***, part of the outboard C-V joint, connects this joint to the wheel hub. The steering knuckle and the front suspension system are also connected to this spindle shaft.



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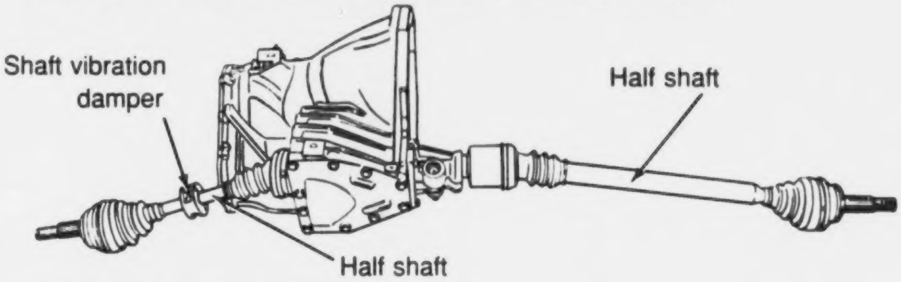
ELIMINATING TORQUE STEER

The fact that one drive axle is longer than the other can create steering problems for a front-wheel drive vehicle with a transversely mounted transaxle. When the vehicle is accelerating, both half shafts twist, but because of its extra length, the longer half shaft twists for a slightly longer time than the shorter shaft. This causes the side where the short shaft is installed to move quicker than the long shaft side.

This condition, called ***torque steer***, causes the vehicle to pivot towards the side where the longer half shaft is located. During acceleration, the vehicle will steer towards the side of the longer half shaft, but during deceleration, the longer shaft untwists, and the vehicle will pivot in the opposite direction. Although this situation creates more of a problem in vehicles with high-torque engines, several drive axle designs have been used to try to eliminate the problems created by torque steer.

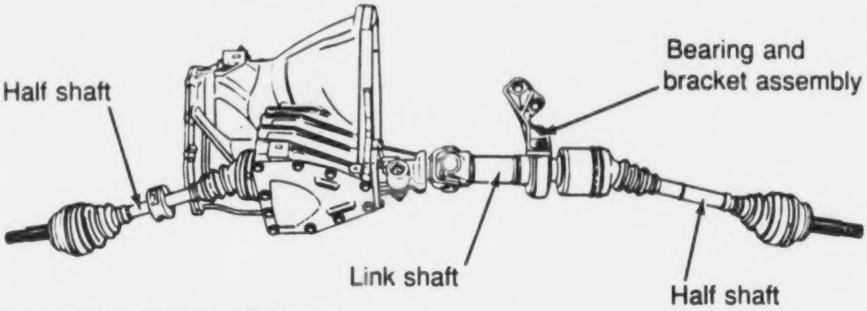
ELIMINATING TORQUE STEER
(Continued)

- Some front drive axles use a thicker, ***hollow half shaft*** for the longer shaft. This helps decrease the amount of twisting in this shaft. (Notice the shaft vibration damper on the shorter half shaft in the following example.)


Shaft vibration damper
Half shaft
Half shaft

Used with permission of Chrysler Corporation.

- Other vehicles use a third shaft called a ***link shaft*** to take up the extra space between two half shafts which are the same length.


Half shaft
Bearing and bracket assembly
Link shaft
Half shaft

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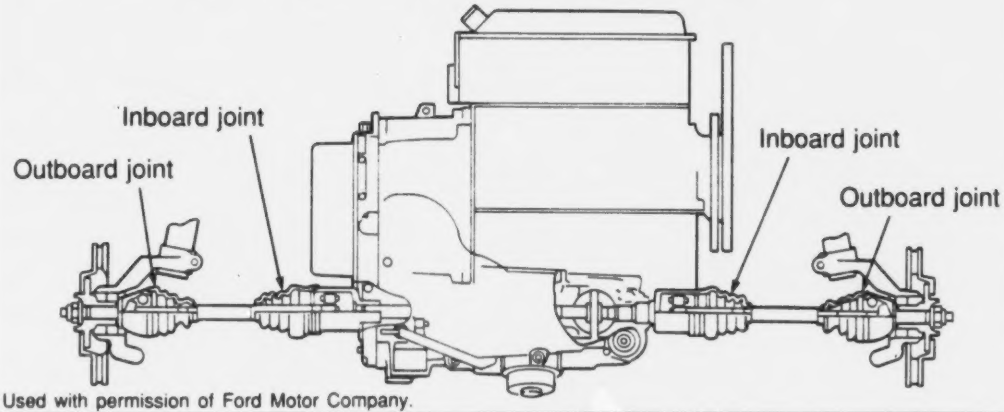
- Still other manufacturers have attempted to control torque steer by designing the transaxle so that both half shafts can be of the same length.


Inboard joint
Outboard joint
Inboard joint
Outboard joint

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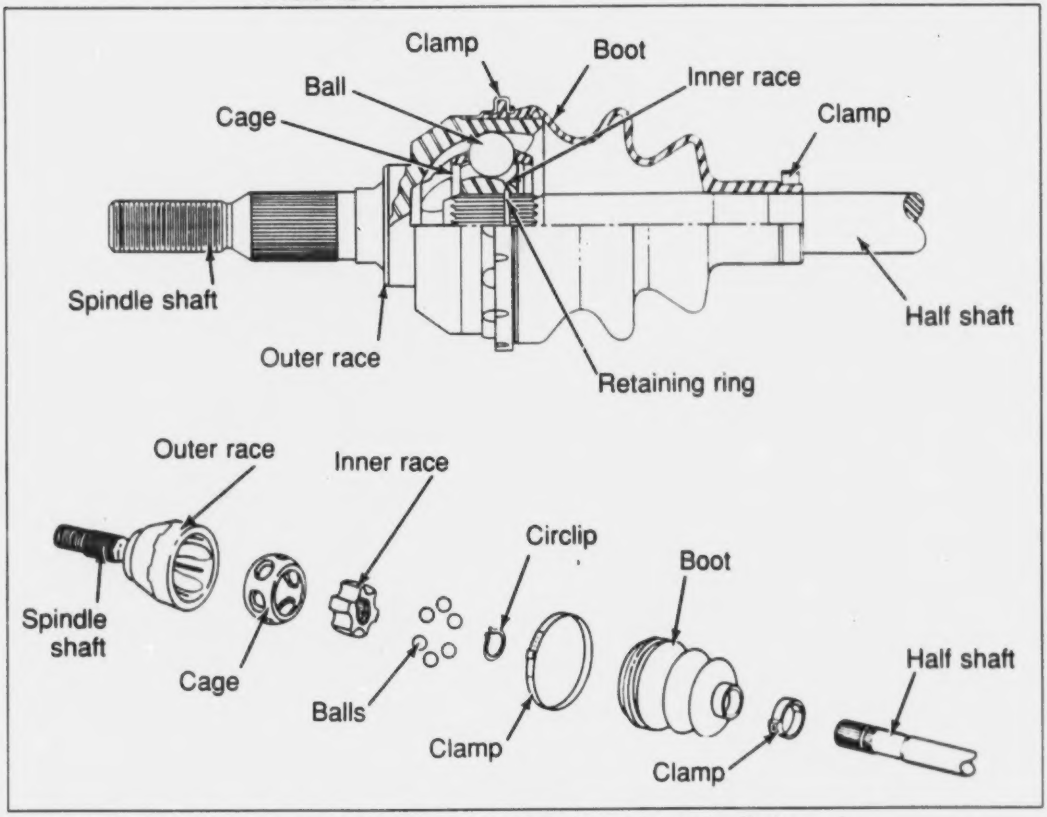
OBJECTIVE 5 **Label four common types of drive axle joints and match the names of their parts to illustrations.**

NOTE: There is a wide variety of types of constant velocity joints used on drive axles. The following are some of the most common.

RZEPPA JOINT

FIGURE 6


Clamp
Boot
Ball
Inner race
Cage
Clamp
Spindle shaft
Half shaft
Outer race
Retaining ring
Outer race
Inner race
Circlip
Boot
Spindle shaft
Half shaft
Cage
Balls
Clamp
Clamp

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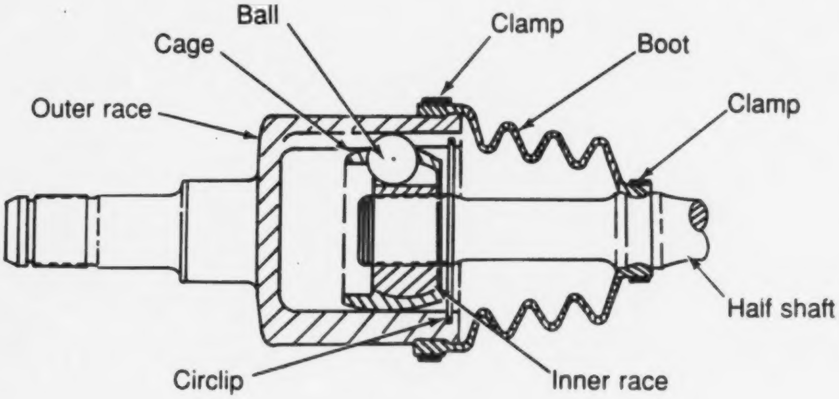
NOTE: ***Rzeppa*** (pronounced *Sheppa*) ***joints*** are the most common type of joint used on front drive axles. Highly flexible, the Rzeppa joint is usually used as an outboard joint, although it can also be used inboard. The short ball grooves and the spindle shaft on the joint pictured shows that this is a ***fixed Rzeppa joint***, used as an outboard joint. (Notice the threads and splines that allow for attachment to the hub.) Look inside the outer race of the joint in the illustration: the ball grooves in both the inner and the outer races of a Rzeppa joint are always curved. The rounded ***bell housing*** on this Rzeppa joint is very common.

DOUBLE OFFSET JOINT

FIGURE 7



Ball
Cage
Clamp
Boot
Clamp
Outer race
Half shaft
Circlip
Inner race

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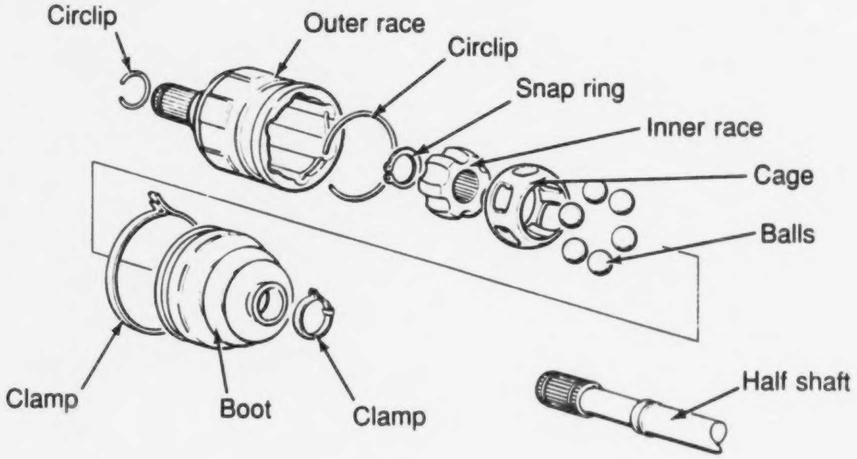

Circlip
Outer race
Circlip
Snap ring
Inner race
Cage
Balls
Clamp
Boot
Clamp
Half shaft

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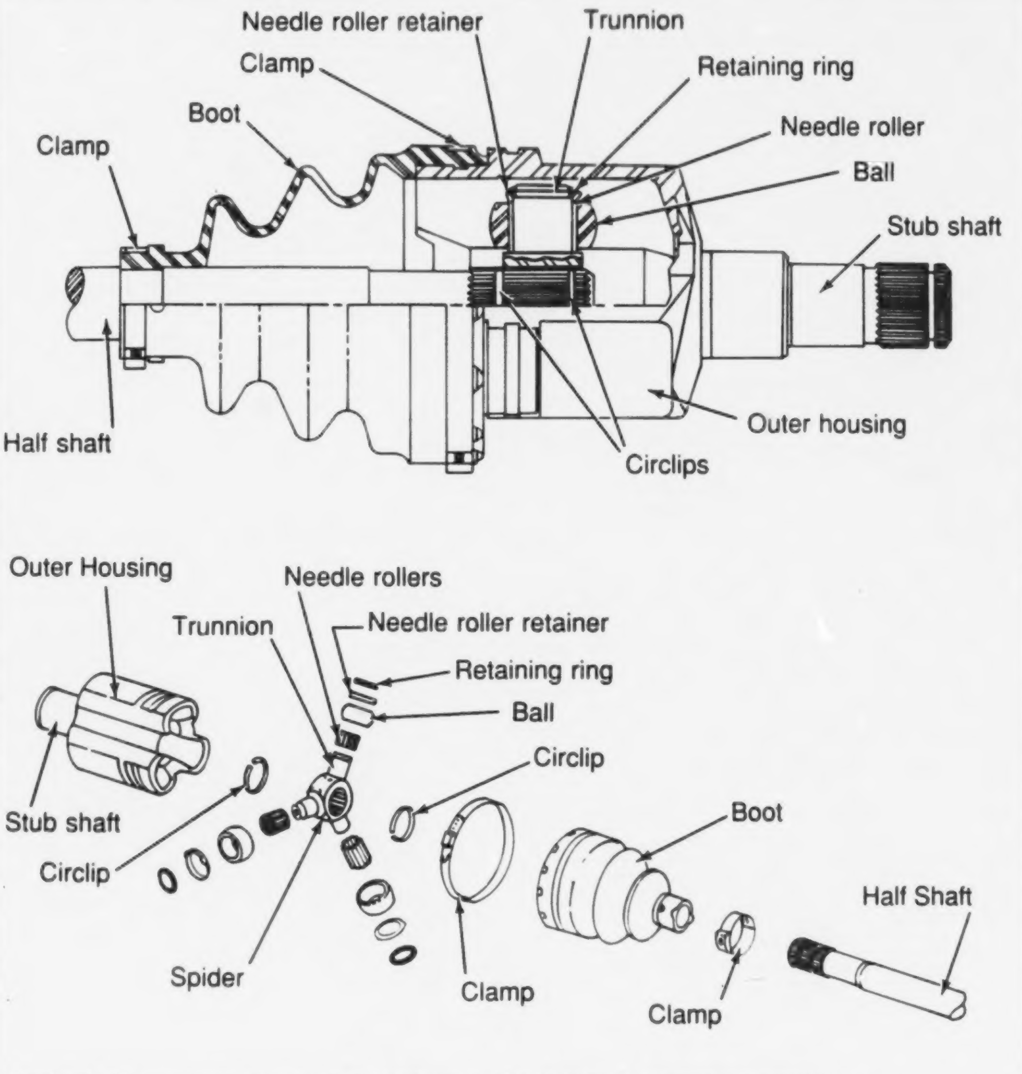
NOTE: A ***double offset joint*** is very similar to a Rzeppa joint, but the ball grooves in the outer and inner races are straight instead of curved. A double offset joint is almost always used as an inboard joint, although it can be used in the outboard position. The long ball races and the stub shaft on the joint pictured show that this joint is used inboard. Double offset joints are being used less and less frequently.

TRIPOD JOINT

FIGURE 8


Needle roller retainer
Trunnion
Clamp
Retaining ring
Boot
Needle roller
Clamp
Ball
Stub shaft
Outer housing
Half shaft
Circlips
Outer Housing
Needle rollers
Trunnion
Needle roller retainer
Retaining ring
Ball
Circlip
Boot
Stub shaft
Circlip
Half Shaft
Spider
Clamp
Clamp

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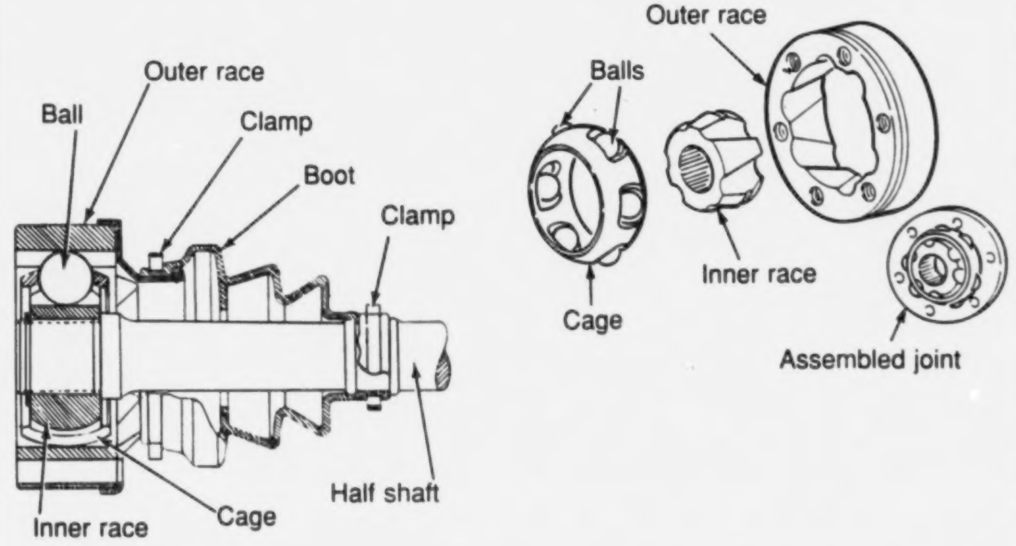
NOTE: ***Tripod joints***, combining the use of balls and needle bearings, are the most common type of inboard joint. The long ball grooves and the stub shaft on the joint pictured show that it is a ***plunging tripod joint***, used as an inboard joint. A ***fixed tripod joint*** has shorter ball grooves and is used as an outboard joint. Tripod joints are also called ***tripode*** or ***tripot*** joints.

CROSS GROOVE JOINT

FIGURE 9


Ball
Outer race
Clamp
Boot
Clamp
Inner race
Cage
Half shaft
Outer race
Balls
Cage
Inner race
Assembled joint

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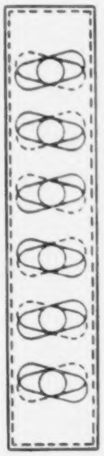
NOTE: A ***cross groove joint*** is most similar to a double offset joint. Its ball grooves are straight, but the ball grooves on the inner race and the grooves on the outer race are both slanted in helical designs which cross each other. The example to the right shows what these grooves would look like if they were laid straight instead of in a cylinder. Cross groove joints are almost always used as inboard joints (called **cross groove *plunging* joints**) .

FIGURE 10



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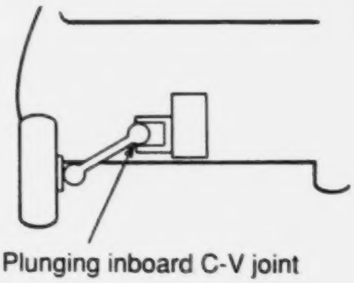
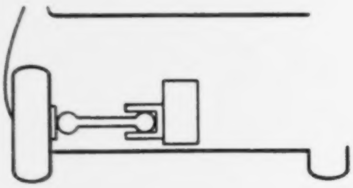
FRONT DRIVE AXLE JOINTS

The front drive axles transfer torque from the transaxle to the front drive wheels. These drive wheels move up and down with the front suspension and move from side to side with the steering. Like drivelines, front drive axles must transport torque over distance and be able to adapt to changes in both angle and length—in this case between the transaxle and the drive wheels. To accomplish this, constant velocity universal joints are used at both ends of each half shaft. These joints are extremely flexible, operating at angles of up to 20% required by the suspension, and 40% required by the steering.

The joints which connect the half shaft to the wheel hub are called ***outboard*** joints. The joints which connect the half shaft to the transaxle are called ***inboard*** joints. Both inboard and outboard joints must be able to adjust for angle changes, but the adjustment for changes in *distance* between the transaxle and the drive wheels is usually made by the inboard joints. For this reason, the inboard joints are sometimes called ***plunging joints*** and outboard joints are called ***fixed joints***. All of the joints mentioned in this objective can be modified to act as either a fixed joint or a plunging joint, but some are used more frequently in one position than another.





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TRANSAXLE AND FRONT DRIVE AXLES TROUBLESHOOTING GUIDE

In addition to the vehicle's service manual, use Supplements 2, 3, and 4, ***Transaxle and Front Drive Axles Performance Diagnosis Chart***, ***Transaxle and Front Drive Axles Noise Diagnosis Chart***, and ***Transaxle and Front Drive Axles Leak Diagnosis Chart***, to assist in diagnosing transaxle and front drive axle problems. You will also need Supplements 1-4, Unit 3, to help you evaluate the possibility of transmission problems that are clutch-related.

1. **Talk to the vehicle's owner.** The first step in diagnosing any automotive problem is to talk to the vehicle's owner about the nature of the problem and the service history of the vehicle. What problems are there in shifting? What gears are noisy? Under what conditions does the problem occur?

2. **Road test the vehicle to verify the problem.** Use Supplement 3, Unit 1, "Making a Diagnostic Road Test," to road test the vehicle. Make sure the transaxle fluid level is correct and warm up the transaxle before you begin. Drive in a quiet area and try to reproduce the problems and noises described to you by the owner. The purpose of this road test should be to verify the problem and to try to determine where the noise you are hearing is coming from.

   When the vehicle has a front-engine, front-wheel drive, this problem is complicated by the fact that many different components are installed in the same area. Any of the following components could be the source of the problem:

   tires
   wheels
   engine
   clutch
   steering
   suspension
   drive axles
   transaxle transmission section
   transaxle differential section

   Watch for the following performance problems:

   - Slipping or jumping out of gear
   - Hard shifting
   - Gears clashing when shifting
   - Cannot be shifted into a gear
   - Cannot be shifted out of a gear
   - Excessive vibration

If there is noise, try to identify (1) the type of noise, (2) the source of the noise, and (3) the conditions under which the noise appears or changes. Drive at various speeds in all gears, accelerating, decelerating, and turning. Use the vehicle's service manual and Supplement 3, "Transaxle and Front Drive Axle Noise Diagnosis Chart," to guide you through the driving conditions that will help you evaluate the noise.

Some transaxle noises are normal and cannot be corrected. The nature of these noises will vary from model to model and the vehicle's service manual will usually alert the specialist to their existence. However, to make sure the noise is normal, the specialist must compare the noise he hears to the operating noise made by other vehicles of the same year, make, and model which are functioning correctly. The following two normal transaxle noises have been identified by Ford Motor Company for vehicles they manufacture:

- **Gear Rattle** is a repetitive metallic impact or rapping noise which occurs on a manual transaxle powertrain when the vehicle is lugging in gear. The rattle noise intensity increases with transaxle operating temperature and engine torque and decreases with increasing vehicle speed. Since the gear ratios have been designed to achieve maximum fuel economy, there may be instances when gear rattle is distinctly noticeable under lugging conditions. This, however, is not detrimental to the engine or transaxle, provided that the appropriate gear ratio is selected for the vehicle speed.
- **Neutral Rollover Rattle** has the same characteristics as gear rattle, except rollover noise occurs with the engine idling, transaxle in neutral, and the clutch engaged. Neutral rollover noise is caused by engine torsional vibrations and will disappear when the transaxle is engaged in gear. The rollover noise intensity increases with transaxle operating temperature and engine torque loading resulting from engine driven accessories (air conditioning and alternator). Neutral rollover noise is inherent in manual transaxles and is not detrimental to the engine or transaxle. However, in vehicles where the engine idle speed is below specification and/or rough, the rollover noise can deteriorate to a level where a harsh clattering noise similar to loose marbles in the transaxle will become audible. Repair or replacement of transaxle components will not correct this condition.

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3. **Make a visual inspection.** During a visual examination, you can eliminate some of the possible causes of noise and performance problems.
   - Examine the transaxle mounts for damage or wear.
   - Check the external parts of the shift linkage for damage, wear, and proper adjustment.
   - Check the transaxle housing for damage.
   - Check for transaxle fluid leaks.

     NOTE: Because the engine and other components are so close together, it is sometimes difficult to determine if a leak is from the transaxle or from the engine or some other source. Use Supplement 4, "Transaxle and Drive Axle Leak Diagnosis Chart," to help you diagnose the source of the leak.
   - Examine the drive axles and drive axle boots for damage, wear, or leaks.

4. **Eliminate the possibility of clutch problems.** Use Supplement 1, Unit 3, "Clutch Troubleshooting Guide," and check to see if the vehicle has clutch problems that could be causing transaxle problems.

5. **Disassemble, inspect, and repair or replace the transaxle or front drive axles.** When making your final diagnosis, remember that most of the various systems and components located in the area of the transaxle and front drive axles are dependent upon each other. If transaxle mounts are broken, they don't just affect the transaxle, they affect the engine and drive axles as well; if a spring is fatigued in the suspension system, it can affect the drive axle operating angle; a broken gear tooth in the transmission section can end up in the differential section. Drivetrain and axles technicians don't just repair vehicles. They think. And making an accurate and complete transaxle diagnosis and repair challenges the best technician.

   Most technicians inspect and evaluate the clutch components at the same time they remove the transaxle to assure that transaxle problems are not clutch-related.

TRANSAXLE AND FRONT DRIVE AXLES PERFORMANCE DIAGNOSIS CHART

Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transaxle jumps or slips out of gear	Worn, damaged, or improperly adjusted shift linkage	Inspect and adjust or replace worn or damaged parts
	Worn or damaged shift linkage cables	Replace shift cables
	Loose brace in shift linkage	Torque brace bolts to specifications
	Shift linkage binding	Inspect and adjust
	Worn or damaged shift assembly	Replace worn or damaged parts
	Excessive end play	Adjust end play
	Worn or damaged gear in transmission section	Replace gear
	Stiff shift lever or shift lever boot	Inspect, lubricate, adjust, or replace
	Damaged shift selector shaft	Replace shift selector shaft
	Improperly installed shift lever boot	Install boot correctly
	Interference between shift lever and console	Inspect and adjust
	Transaxle loose or improperly mated to engine housing	Clean and inspect mating surfaces; torque bolts to specifications
	Loose, worn, or damaged transaxle mounts	Inspect, adjust, or replace; torque to specifications

TRANSAXLE AND FRONT DRIVE AXLES PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transaxle jumps or slips out of gear (continued)	Worn bushing	Replace bushing
	Loose or broken bearing on input gear shaft	Replace input shaft bearing
	Loose input shaft mounting nut	Tighten nut
	Worn or damaged internal transaxle part	Replace damaged parts
Transaxle shifts hard	Interference between shift lever and console	Inspect and adjust
	Shift linkage binding	Adjust shift linkage
	Worn or damaged shift linkage	Replace shift linkage
	Worn or damaged shift forks	Replace shift forks
	Damaged shift assembly	Replace damaged parts
	Low transaxle lubricant	Fill transaxle lubricant
	Improper shift linkage adjustment	Correct shift linkage adjustment
Transaxle gears clash when shifting	Clutch not disengaging properly	Inspect and adjust or replace parts
	Improper clutch pedal free travel adjustment	Adjust free travel
	Low clutch hydraulic fluid	Fill clutch hydraulic fluid
	Worn or damaged synchronizer assembly	Replace synchronizer assembly
	Improperly installed clutch disc	Inspect and install correctly
	Improper shift linkage adjustment	Correct shift linkage adjustment
	Worn or damaged shift forks	Replace shift forks
	Excessive end play	Adjust end play

TRANSAXLE AND FRONT DRIVE AXLES PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transaxle will not shift into one certain gear	Worn or damaged synchronizer assembly	Replace synchronizer assembly
	Worn or damaged speed gear	Replace speed gear
	Interference in shift linkage	Inspect and adjust shift linkage
	Interference in shift assembly	Inspect and adjust; replace as necessary
	Damaged shift linkage	Replace shift linkage
Transaxle will not shift into reverse	Worn or damaged reverse idler gear assembly	Replace worn or damaged parts
	Damaged shift linkage	Replace shift linkage
	Worn or damaged internal transaxle part	Replace worn or damaged parts
Transaxle cannot be shifted out of a gear	Damaged synchronizer assembly	Replace synchronizer
	Worn or damaged reverse idler gear assembly	Replace reverse idler gear assembly parts
	Worn or damaged shift assembly	Replace worn or damaged parts
	Damaged shift linkage	Replace damaged parts
Excessive vibration	Tire problem	Inspect and repair or replace
	Worn C-V joint	Replace C-V joint
	Bent drive axle shaft	Replace bent shaft
	Rough wheel bearing	Replace wheel bearing
	Incorrect drive axle angle	Inspect and correct
Vibration at low speed	Bent drive axle shaft	Replace bent shaft
Vibration in steering wheel at highway speeds	Improper front wheel balance	Balance front wheels
Vibration or shudder at highway speeds	Tire problem	Inspect and repair or replace
	Loose or worn C-V joint	Replace C-V joint

TRANSAXLE AND FRONT DRIVE AXLES PERFORMANCE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Vibration or shudder at highway speeds (continued)	Loose steering mount	Inspect and repair
Vibration or shudder during acceleration	Worn or damaged C-V joint	Replace C-V joint
	Fatigued front springs are causing incorrect drive axle angle	Replace front springs
	Sticking C-V joint	Inspect and lubricate or replace C-V joint

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TRANSAXLE AND FRONT DRIVE AXLES NOISE DIAGNOSIS CHART

Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Rough growling in neutral	Worn or damaged input shaft bearing	Replace bearing
	Improper clutch pedal free travel adjustment	Adjust free travel
Knock at low speeds	Worn C-V joint	Replace C-V joint
	Worn differential side gear counterbore	Replace side gear and/or differential case
Rattling at low speeds	Damaged bearing	Replace bearing
Humming at high speeds	Worn bearing	Replace bearing
Clunking during acceleration or deceleration	Worn inboard C-V joint	Replace C-V joint
	Worn differential pinion shaft	Replace differential pinion shaft
	Loose transaxle mounts	Inspect and torque to specifications
	Worn differential side gear counterbore	Replace side gear and/or differential case
Clicking while turning	Worn C-V joint	Replace C-V joint
	Bent drive axle shaft	Replace drive axle shaft
Whining when turning	Worn or damaged gears in differential case	Replace gears
Noisy when turning	Damaged differential pinion gears	Replace gear
	Damaged or frozen differential side bearing	Replace differential side bearing
	Worn or damaged thrust washer in differential section	Replace thrust washer

TRANSAXLE AND FRONT DRIVE AXLES NOISE DIAGNOSIS CHART (CONTINUED)

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Noisy when turning (continued)	Damaged differential pinion shaft	Replace differential pinion shaft
Clicking in any one gear range	Damaged gear teeth in transmission section	Replace damaged gear; inspect internal parts
Rough growling from transaxle area in all gears	Worn or damaged output or intermediate shaft bearing	Replace bearing
Whining in all gears	Worn or damaged output shaft drive gear and/or differential ring gear	Replace gear; inspect internal parts
Noisy in all gears	Low transaxle lubricant	Fill transaxle lubricant; check for leak
	Incorrect transaxle lubricant	Drain and replace
	Improper ring to output drive gear backlash	Correct backlash
	Improper transaxle alignment	Correct alignment
	Broken transaxle mounts	Replace mounts
	Loose transaxle to engine mounting bolts	Torque bolts to specifications
	Incorrect drive axle angle	Inspect and correct
	Worn or damaged bearing	Replace bearing
	Worn drive axle splines	Replace worn parts
	Damaged gear in transmission section	Replace gear
	Damaged differential gear	Replace gear
	Damaged or frozen differential side bearing	Replace differential side bearing
	Worn or damaged input and/or output shaft	Replace shaft
Noise the same in drive or coast	Road noise	None
	Tire noise	Inspect tires; rotate or replace if needed
	Worn or damaged front wheel bearing	Replace front wheel bearing

TRANSAXLE AND FRONT DRIVE AXLES NOISE DIAGNOSIS CHART (CONTINUED)

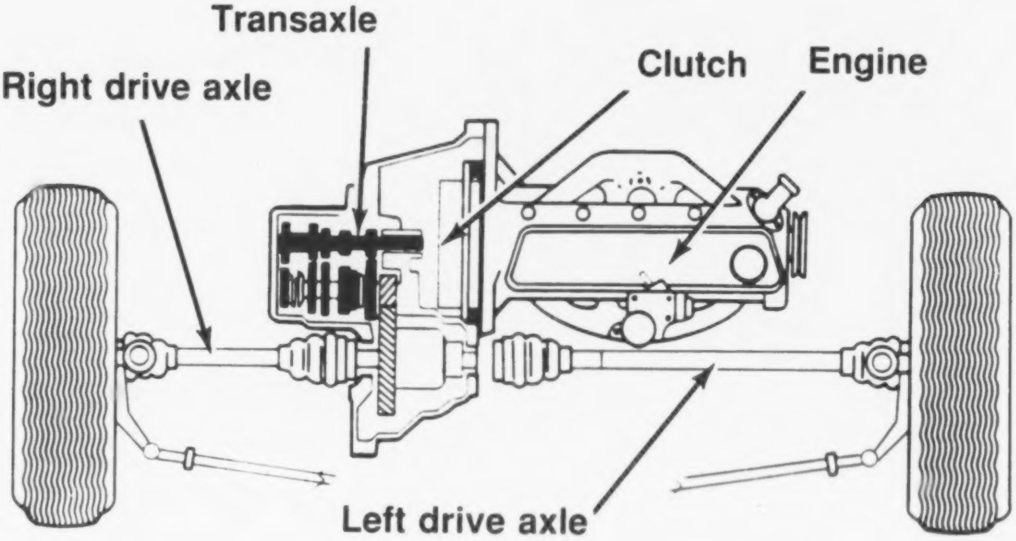
CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Noise the same in drive or coast (continued)	Incorrect drive axle angle	Inspect and correct
Noise changes with road surface	Road noise	None
	Tire noise	Inspect tires; rotate or replace if needed
Tone of noise lowers as speed lowers	Tire noise	Inspect tires; rotate or replace if needed
Noise from area of one front wheel	Damaged wheel and/or tire	Inspect and repair or replace damaged parts
	Worn or damaged wheel bearing	Replace wheel bearing

TRANSAXLE AND FRONT DRIVE AXLES LEAK DIAGNOSIS CHART

Causes that are more probable are listed first.

POSSIBLE CAUSES	CORRECTIVE ACTION
Too much lubricant	Remove lubricant to the correct level
Plugged vent	Unclog vent
Mist from transaxle housing vent	Normal condition—no action needed
Bad drive axle seal	Replace seal
Worn or damaged boot on front drive axle joint	Replace boot and inspect joint for damage
Lack of sealant between mating surfaces of transaxle housing	Clean mating surfaces and replace sealant
Loose or missing expansion plug	Replace expansion plug
Wrong type of lubricant	Drain and replace with correct lubricant
Worn or damaged shift lever seal	Replace seal
Loose or broken input shaft bearing retainer	Replace bearing retainer
Other component leaking	Check engine and power steering

Front-Wheel Power Train


Transaxle
Right drive axle
Clutch
Engine
Left drive axle

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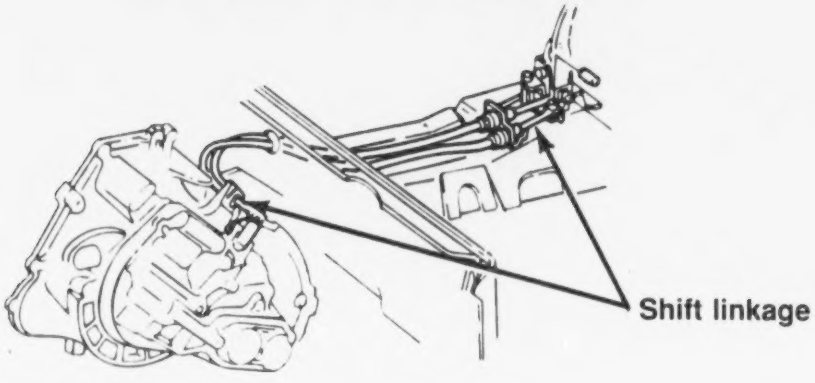
Manual Transaxle


Shift linkage

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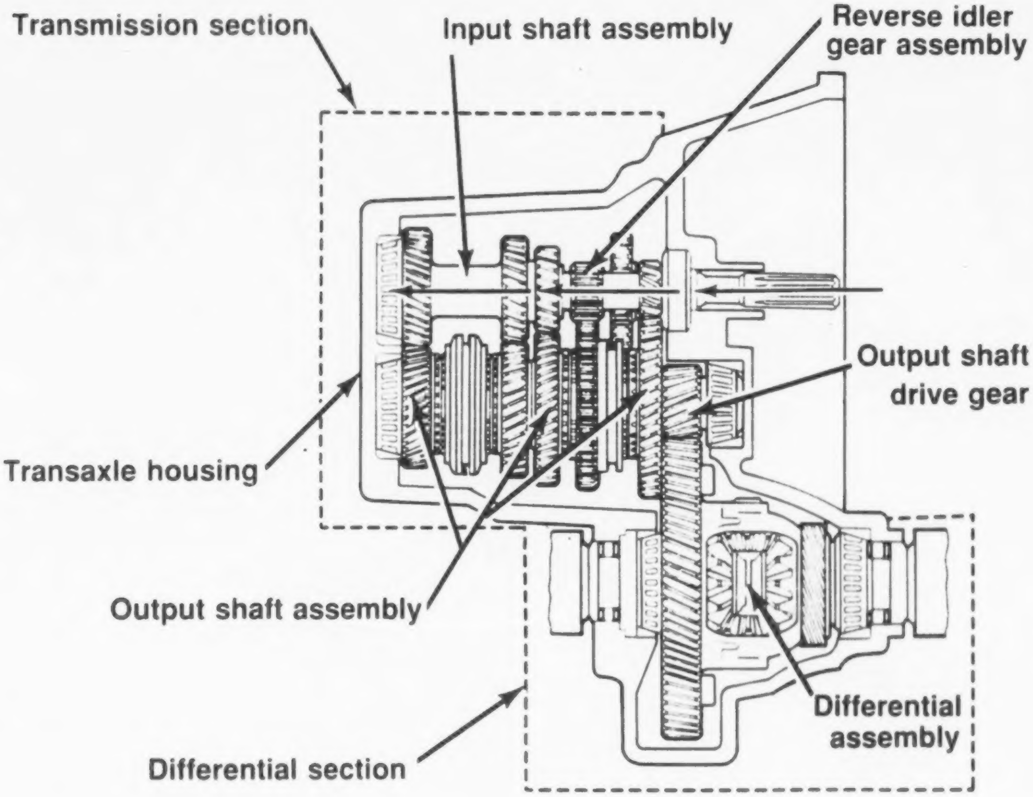
Transmission section
Input shaft assembly
Reverse idler gear assembly
Output shaft drive gear
Transaxle housing
Output shaft assembly
Differential assembly
Differential section

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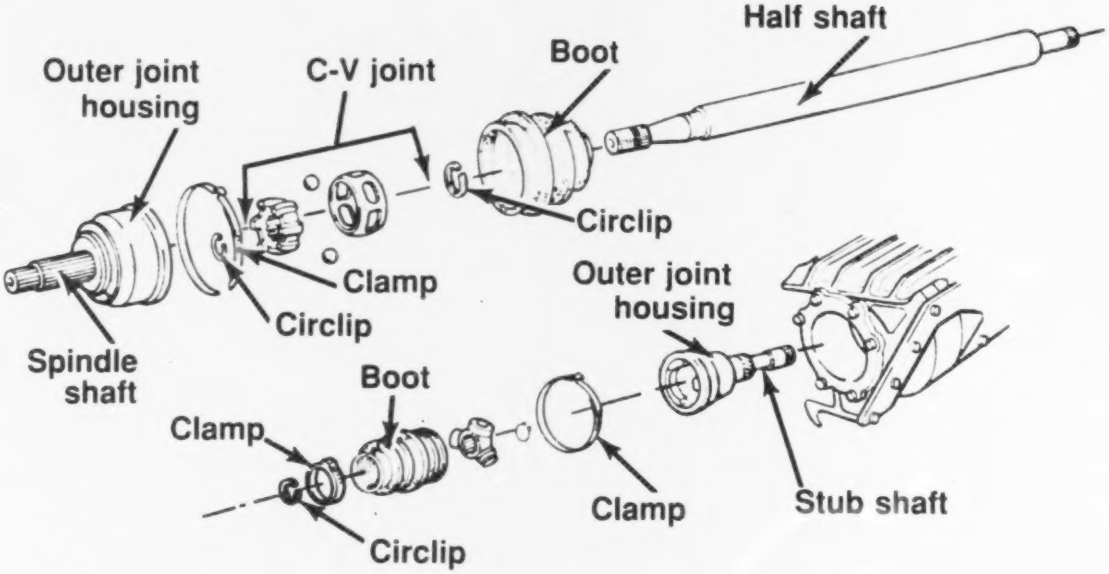
Front Drive Axle


Half shaft
Boot
Outer joint housing
C-V joint
Circlip
Clamp
Circlip
Spindle shaft
Outer joint housing
Boot
Clamp
Circlip
Clamp
Stub shaft

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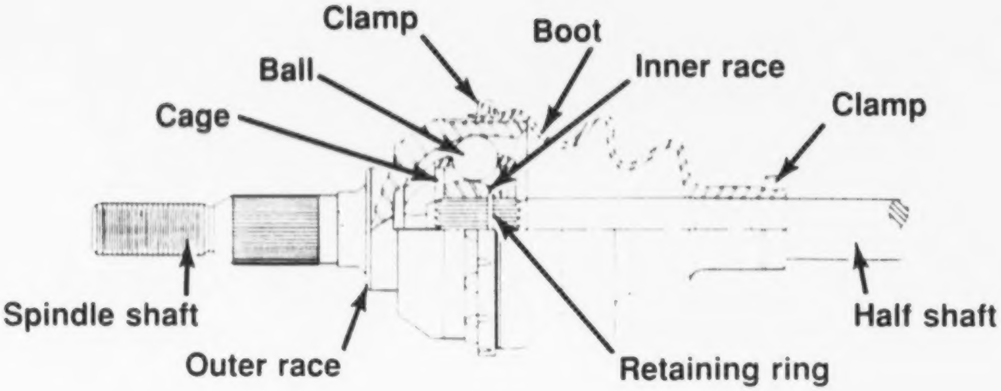
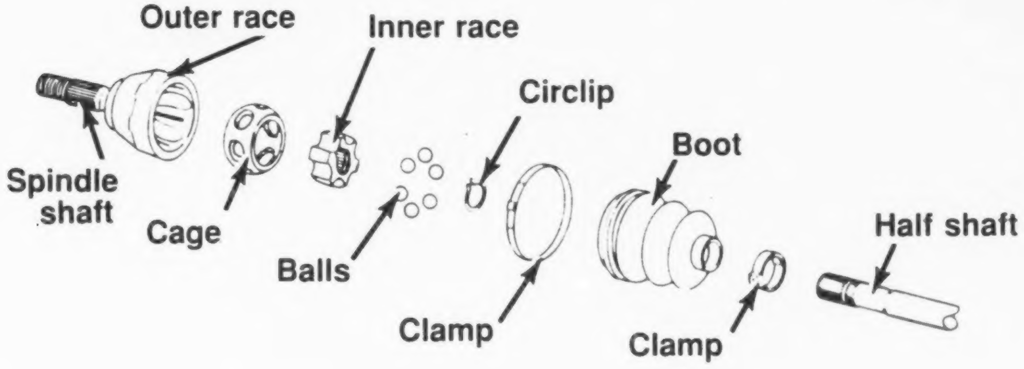
Rzeppa Joint


Clamp
Boot
Ball
Inner race
Clamp
Cage
Spindle shaft
Half shaft
Outer race
Retaining ring


Outer race
Inner race
Circlip
Boot
Spindle shaft
Cage
Half shaft
Balls
Clamp
Clamp

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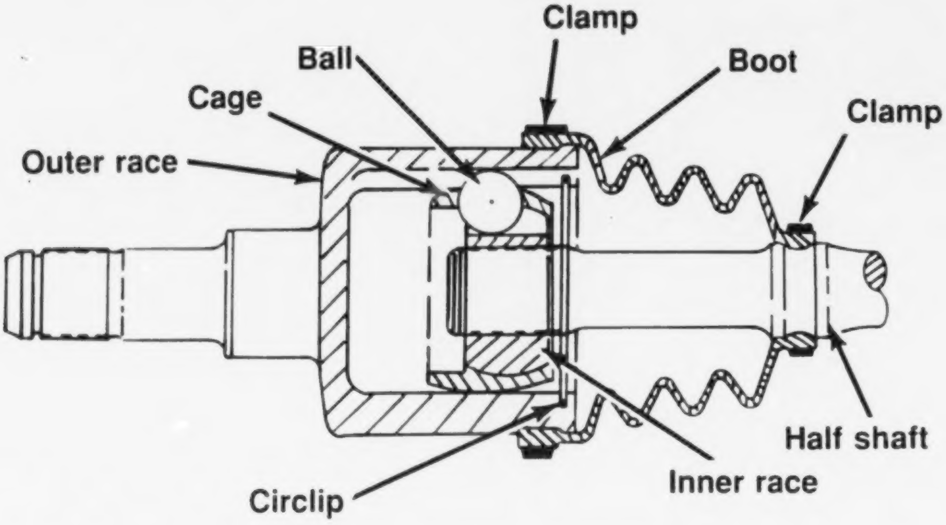
Double Offset Joint


Clamp
Ball
Boot
Cage
Clamp
Outer race
Half shaft
Inner race
Circlip

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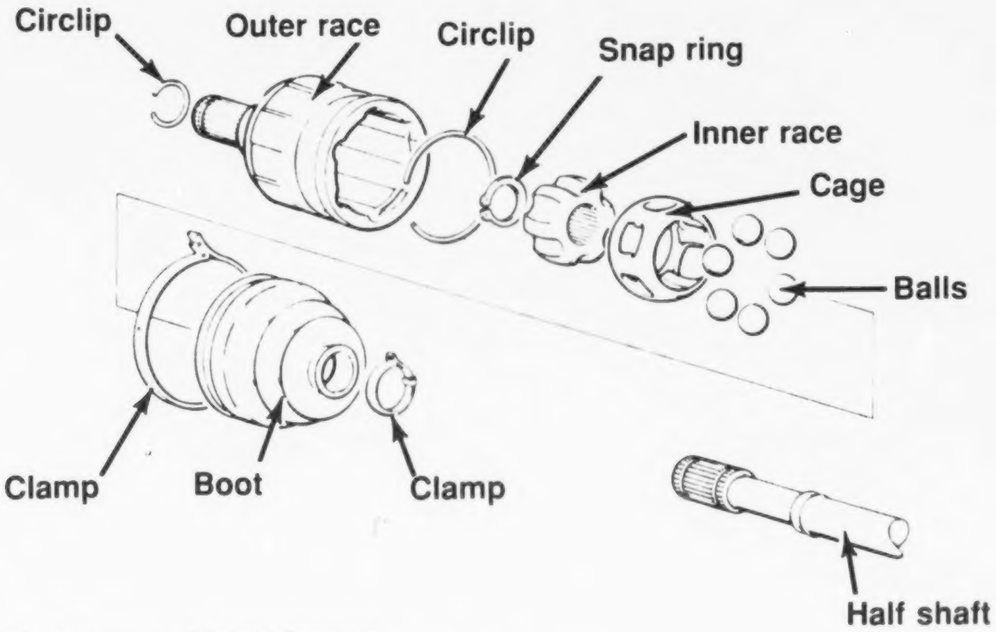
Circlip
Outer race
Circlip
Snap ring
Inner race
Cage
Balls
Clamp
Boot
Clamp
Half shaft

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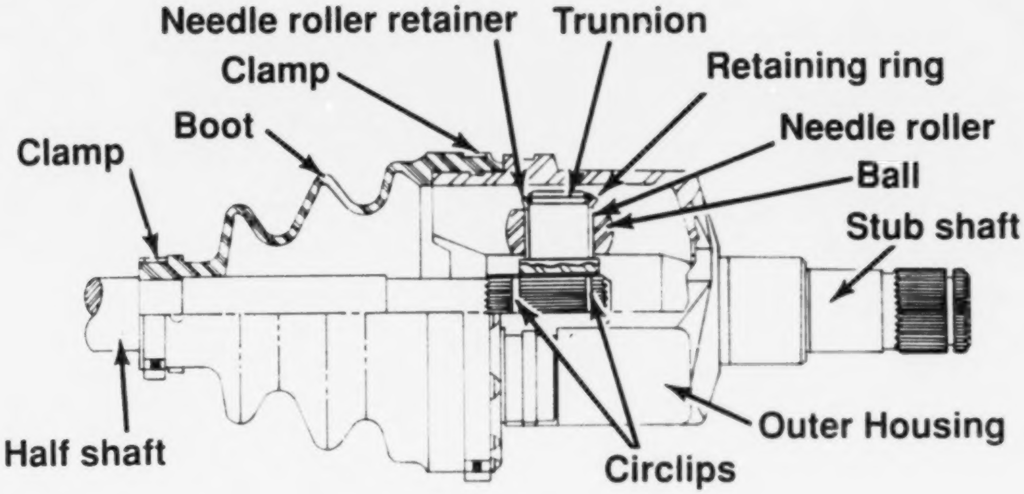
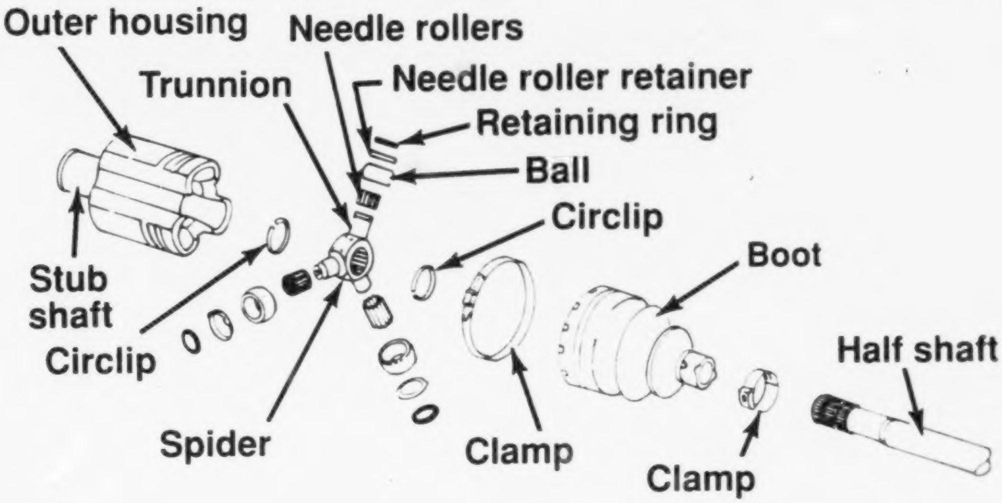
Tripod Joint


Needle roller retainer
Trunnion
Clamp
Retaining ring
Boot
Needle roller
Clamp
Ball
Stub shaft
Half shaft
Outer Housing
Circlips


Outer housing
Needle rollers
Trunnion
Needle roller retainer
Retaining ring
Ball
Circlip
Boot
Stub shaft
Circlip
Half shaft
Spider
Clamp
Clamp

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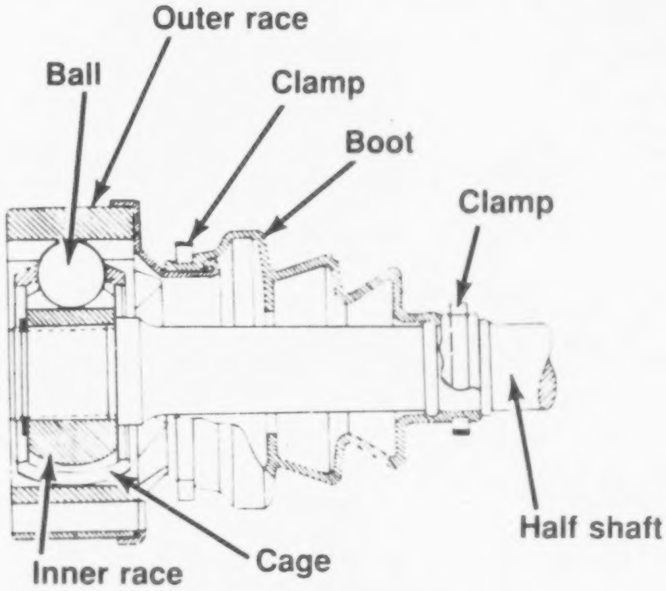
Cross Groove Joint


Outer race
Ball
Clamp
Boot
Clamp
Half shaft
Cage
Inner race

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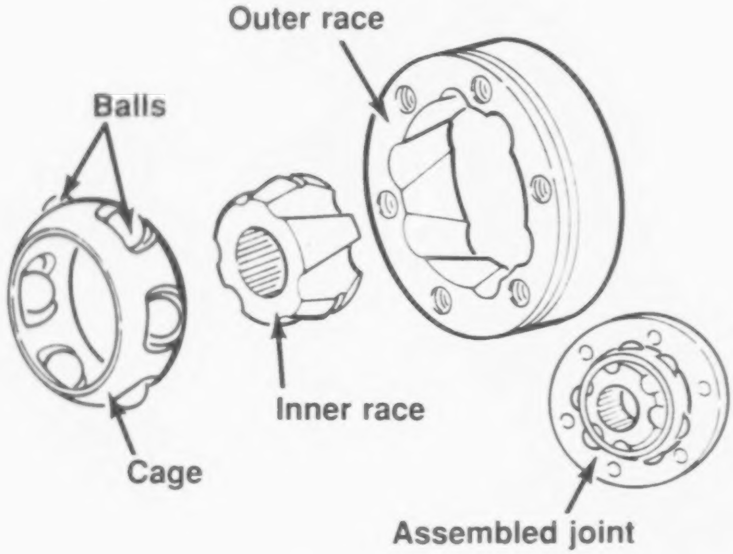
Outer race
Balls
Inner race
Cage
Assembled joint

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ASSIGNMENT SHEET 1

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

NAME ______________________________ SCORE ______

OBJECTIVE 14

Diagnose manual transaxle and front drive axle noise and performance problems.

INTRODUCTION

Diagnosing transaxle and front drive axle noise and performance problems can be a real challenge to the automotive technician because of the number of closely related automotive systems and components that are located in this area. All these systems must be considered when making a diagnosis.

Use Supplements 1, 2, 3, and 4, ***Transaxle and Front Drive Axles Troubleshooting Guide***, ***Transaxle and Front Drive Axles Performance Diagnosis Chart***, ***Transaxle and Front Drive Axles Noise Diagnosis Chart***, and ***Transaxle and Front Drive Axles Leak Diagnosis Chart***, to assist in diagnosing transaxle and first drive axle problems.

DIRECTIONS

Study the Supplements mentioned just above and then read each of the following questions carefully. Select the answer for each that is *most* correct. Write the correct letter in the blank.

______1. A vehicle is vibrating excessively during acceleration, and there is a tear in the boot of the drive axle joint. What is the **most** likely cause of the vibration?

A. Damaged shift linkage
B. Worn synchronizer assembly
C. Damaged C-V joint
D. Incorrect drive axle angle

______2. In checking for a transaxle leak, you discover that a fine mist is coming from the vent in the transaxle housing. Technican A recommends that you replace the vent. Technican B says that this a normal condition. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

______3. During a test drive to diagnose a transaxle problem, you notice a noise coming from the front of the vehicle. What could be the source?

A. Transaxle
B. Clutch
C. Engine
D. All of the above

______4. Which performance problem could be a result of a bent front drive axle?

A. Clashing gears when shifting
B. Transaxle jumping out of gear
C. Vehicle cannot be shifted into a gear
D. Excessive vibration

______5. Which of the following symptoms is **not** caused by a worn C-V joint on the front drive axle?

A. Clunking during acceleration or deceleration
B. Knock at low speeds
C. Clicking while turning
D. Clicking in any one gear range

______6. While the engine is idling in neutral, there is a repeated rapping noise from the transaxle on a Ford vehicle. Technican A says it may be neutral rollover rattle. Technican B says if it is rollover rattle, it will stop if you put the vehicle in gear. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

______7. A front end noise that occurs only while you are turning the vehicle is **most** likely coming from which of the following?

A. Transaxle differential section
B. Shift linkage
C. Clutch
D. Bearing

______8. The gears on the transaxle clash when they are shifted. Technican A plans to remove and disassemble the transaxle to make repairs. Technican B wants to check the clutch hydraulic fluid first. Who is right?

A. Technican A
B. Technican B
C. Both Technican A and Technican B
D. Neither Technican A nor Technican B

______9. A noise that changes with the road surface is probably from the road or the:

A. Tires
B. Transaxle
C. Exhaust
D. Front drive axles

_____10. What other component is usually checked when the transaxle is removed?

A. Front drive axles
B. Suspension
C. Steering
D. Clutch

ASSIGNMENT ANSWERS

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

ASSIGNMENT SHEET 1

1. C
2. B
3. D
4. D
5. D
6. C
7. A
8. B
9. A
10. D

JOB
SHEET 1

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 7A

Inspect, adjust, and replace transaxle shift linkage components located outside the transaxle housing.

INTRODUCTION

Transaxle shift linkages are usually either a two-cable type or a rod and lever arrangement. The two-cable type is most common. Although there are some similarities between the shift linkage on a transmission and one on a transaxle, there are many differences. Since the part of the shift linkage inside the transaxle housing operates shift forks which move back and forth on rails parallel to the drive axles, a special assembly is required inside the housing to change the movement coming from the gear shift lever 90°. The position of the engine in relation to the shift linkage also becomes a problem in a front-wheel drive vehicle. (See box.)

The individual design of the transaxle and its position in the power train are additional factors which influence the design of the shift linkage that is found on the vehicle. Because there are so many different shift linkage designs, it is not possible to give a standard procedure for adjusting them. Some, in fact, are not adjustable at all. You should always follow the procedure outlined in the vehicle's service manual carefully.

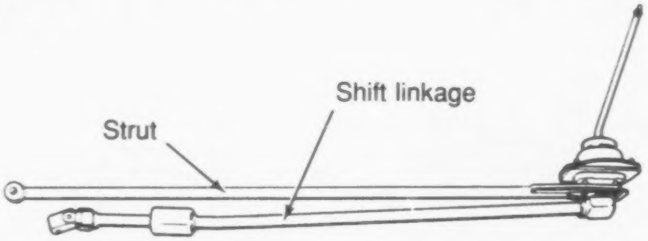
Many of the guidelines used for the adjustment of rod and lever and cable type clutch linkages will prove useful in adjusting the same types of transaxle shift linkages. These guidelines are found in Job Sheets 1 and 2, Unit 4, *Service Manual Transmissions*. Because of the close arrangement of components in the engine compartment of a front-engine, front-wheel drive vehicle, it is always a good idea to disconnect the negative battery cable before adjusting the shift linkage.

TORQUING-OVER

When an engine speeds up, it twists slightly in the direction opposite to the crankshaft rotation. This condition is called ***torquing-over***. Other than pulling slightly on the power train mounts, torquing-over causes little problem in a front-engine, rear-wheel drive power train. There is enough side-to-side flexibility in the shift linkage to allow for the twisting. However, in a front-engine, front-wheel drive power train, the twisting acts directly on the shift linkage since the shift linkage connects perpendicular to the transaxle. The twisting caused by torquing-over can cause the engine to pull on the shift linkage, damaging the linkage, causing it to shift into another gear, or causing constant adjustment problems. (Continued on the next page.)

TORQUING-OVER
(Continued)

Two methods are used to eliminate the problems torquing-over creates in the shift linkage of front-wheel drive vehicles. (1) Most vehicles use a flexible, cable-type shift linkage which won't get out of adjustment during torquing-over. (2) When a rod and lever type shift linkage is used between the transaxle and the shift mechanism inside the vehicle, struts are often installed parallel to the shift linkage. (See illustration.) These struts brace the linkage against the twisting action and minimize the bad effects. The placement and design of the transaxle mounts may provide additional bracing against torquing-over.



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It is important to understand the principles behind such conditions as torquing-over, because when a technician diagnoses transaxle difficulties, he or she must keep in mind that some vibration or performance problems may result from design problems rather than any deficiency in the performance of the components.

EQUIPMENT AND MATERIALS

- Vehicle with a manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheets 1 and 2, Unit 4***
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

OBJECTIVE 7B

Remove and replace front drive axles.

INTRODUCTION

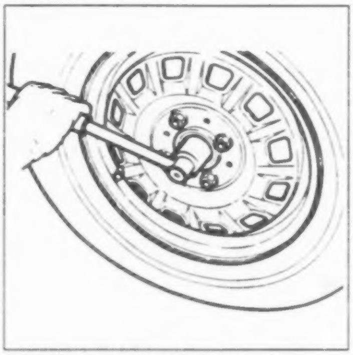
Front drive axles must be removed whenever the transaxle is removed or whenever any part of the drive axle is serviced or replaced. The outboard end of the drive axle is supported by the steering knuckle, a multi-purpose component which houses the axle bearings, supports the front suspension, and is the attachment point for the steering gear and brakes. The inboard end of the drive axle is most commonly installed in the side gear inside the differential section of the transaxle.

Front drive axles are much more complicated than rear drive axles, and because their design varies from vehicle to vehicle, it is not possible to give a standard procedure for removing and replacing them. Use the appropriate service manual and the following guidelines.

Guidelines

- Before you raise the vehicle, have someone step on the brakes while you loosen the hub nut. This resistance will allow you to loosen the nut much more easily than if you raised the vehicle first. (Figure 1)
- Drain the transaxle lubricant before you remove the drive axle.

FIGURE 1



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- Drive axle boots can be easily damaged—install a boot protector around each boot to protect it before you remove the drive axle from the vehicle. (Figure 2)

- Sometimes parts of the suspension system must be disconnected before the drive axle can be removed. Be sure to follow the recommended procedures for such removal.

- When you remove the brake caliper and rotor, use a piece of wire to support the caliper—never let it hang by its hose. (Figure 3)

- If the inboard joint is a tripod joint, it must be held together while you are removing the drive axle, or it may separate entirely and part of the axle will drop to the floor.

FIGURE 2

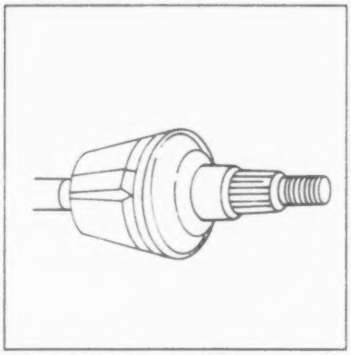

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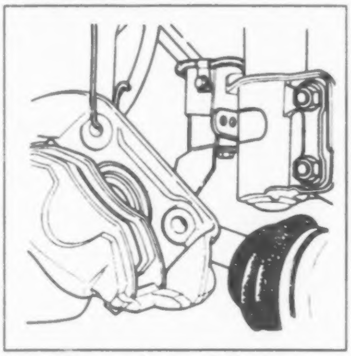
FIGURE 3



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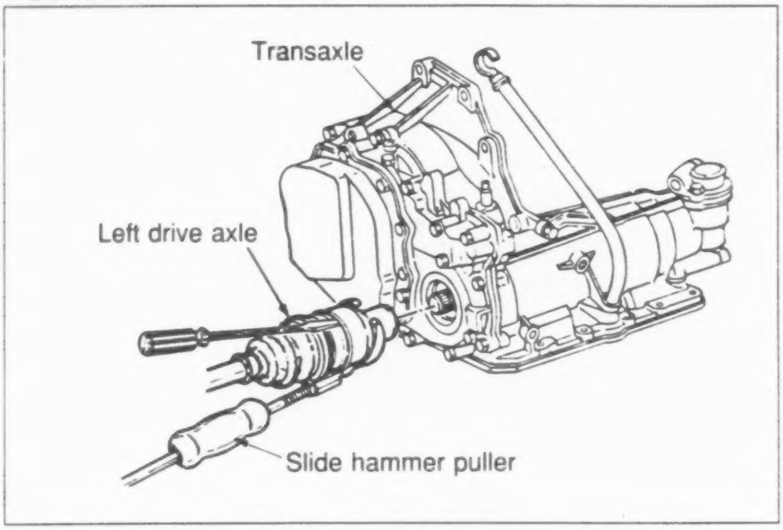
- Usually the inboard stub axle can be removed from the differential assembly with a special tool. (Figure 4)

FIGURE 4



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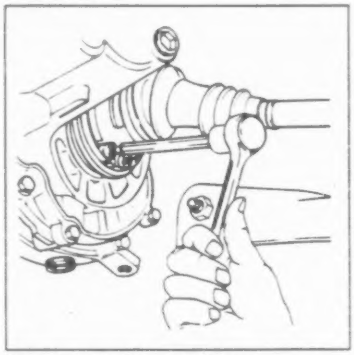
- Sometimes the outer housing of the inboard C-V joint is a flange which is bolted to the transaxle housing. When these bolts are removed, the inboard joint can be removed. (Figure 5)

FIGURE 5



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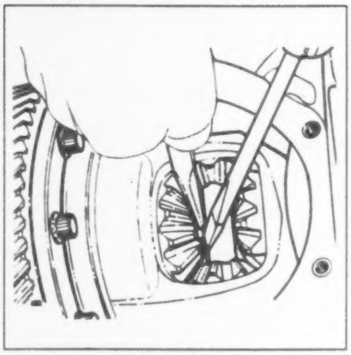
- Occasionally, the stub shaft may be held in place inside the differential by a C-lock or snap ring which must be removed before the shaft can be removed. (Figure 6)

  NOTE: When this is the case, there is a cover over the transaxle's differential section which can be removed to allow you to remove the C-lock.

FIGURE 6



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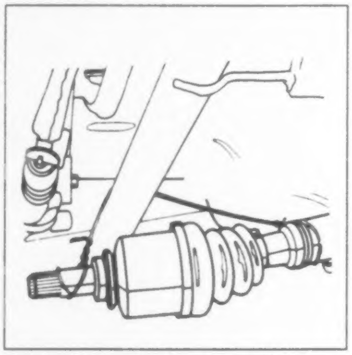
- Use a wire to support the inboard end of the axle while you remove the outboard end. (Figure 7)

FIGURE 7



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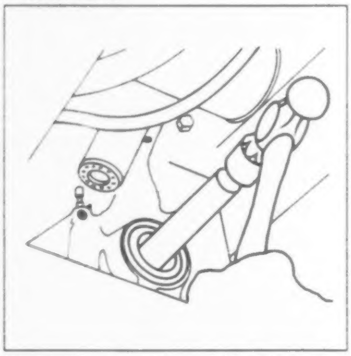
- On some vehicles, a special tool must be installed to keep the differential gears in place while the axle is off the vehicle. (Figure 8)

FIGURE 8



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- A puller can be used to push the spindle axle from the hub. (Figure 9)

- Carefully support both drive axle joints when removing the drive axle to avoid damage that can occur if the ends of the axle hang at the joints. (Figure 10)

FIGURE 9

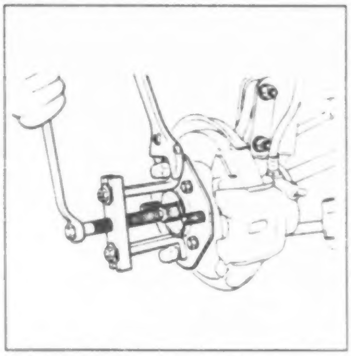

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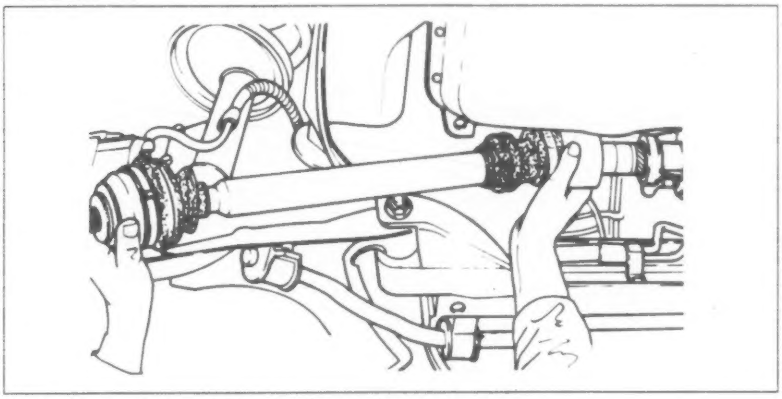
FIGURE 10



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- Once the drive axles are removed, make sure no one starts the engine and engages the clutch, or the differential assembly in the transaxle will be damaged.

- Always use new circlips when reassembling the axle.

- When replacing the drive axle, support the inboard C-V joint with your hand while you align the splines of the stub shaft with the differential side gear.

  NOTE: This joint is probably a tripod joint and may come apart if not supported properly.

- After the stub shaft splines are meshed with the differential side gear, push in on the joint housing to seat the circlip in the side gear groove.

  NOTE: Tap the outer end of the drive shaft with a plastic-faced mallet if more force is needed to seat the circlip.

- Pull out on the outer housing of the inboard joint to make sure the stub shaft is seated properly.
- When replacing the outboard end of the drive axle, follow the manufacturer's instructions exactly to avoid damaging the hub bearing assemblies.

EQUIPMENT AND MATERIALS

- Front-engine, front-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 3

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 7C **Inspect, remove, and replace front drive axle boots.**

INTRODUCTION

The constant velocity joints on front drive axles must be kept clean and well-lubricated, or the entire axle will fail. The boot around a front drive axle joint keeps dirt and moisture out of the joint and keeps joint grease in. A torn boot is the most common cause of joint failure, however, any condition which allows moisture and dirt in or allows grease to leak out will cause a C-V joint to fail.

Boots should be inspected periodically as a part of preventive maintenance for the front drive axle. The boot should be replaced if there is any damage or deterioration, however slight. Whenever a boot is replaced, the grease in the joint should be inspected carefully for contamination. If there is a large tear, or the grease is dirty, the joint probably needs replacement. Boots should also be replaced whenever a C-V joint is serviced or replaced.

A new boot is installed by either removing the axle and installing a new boot over the joint or by installing a split boot (See box below.) over the joint while the axle remains on the vehicle. Boot replacement kits are available which contain all necessary parts, including special C-V joint grease which is high in graphite content. C-V joint replacement kits also ordinarily contain a new boot and grease for the joint being replaced. Boots are manufactured from several types of material—rubber, neoprene, silicone. Make sure that the replacement boot you select is of equal or better quality than the original boot.

SPLIT BOOTS

A split boot is a boot which is cut so it can be installed without removing the drive axle joint. Installing a split boot rather than a new manufacturer-recommended boot saves time, but the possibility of leaks from an improperly glued split boot increases the chance of boot and joint failure later. It can be difficult to install a split boot properly. The technician must reach over his or her head, working in a very small space, to fill the boot with joint grease and align and glue the edges evenly. Manufacturers recommend that drive axle boots be replaced with the original type of boot.

EQUIPMENT AND MATERIALS

- Front-engine, front-wheel drive vehicle
- Appropriate service manual
- Hoist or jack stands
- Eye protection
- Shop light
- Shop towels
- Bench vise
- Masking tape
- Side cutting pliers
- Hammer
- Brass drift
- Boot replacement kit or joint replacement kit
- Boot clamping tool
- Arbor press (if the boot has a boot retainer)

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect front drive axle boots

1. Set the vehicle in neutral and raise it on a hoist or jack stands so the front drive axle boots are visible.

2. Use a shop light to examine the inner sidewalls, fenders, and suspension components for grease that may be a sign of a torn boot.

3. Inspect all boots for nicks, tears, or other signs of damage or deterioration.

4. Rotate the drive wheel to expose all sides of the boots for inspection.

   CAUTION

   Make sure the boot does not catch and tear on suspension parts as you rotate the wheel. If it seems to be catching, try pushing up on the control arm while you rotate the wheel.

5. Pinch the boot material between your fingers and check for signs of cracking.

6. If the boot is torn or badly damaged, you must remove the axle and inspect the C-V joint for damage.

7. If there is a nick or slight damage, cut away part of the boot and examine the joint grease for contamination.

8. If the grease is contaminated, remove the axle and inspect the C-V joint for damage.

9. If the grease is not contaminated and no symptom of joint failure exists, it may be possible to replace the boot with a split boot without removing the drive axle.

10. Replace the boot if there is any sign of damage or deterioration.

PROCEDURE

Remove and replace front drive axle boots

1. Remove the front drive axle from the vehicle. (See Job Sheet 2.)

2. If possible, secure the drive axle in a bench vise during the removal and replacement of the boots.

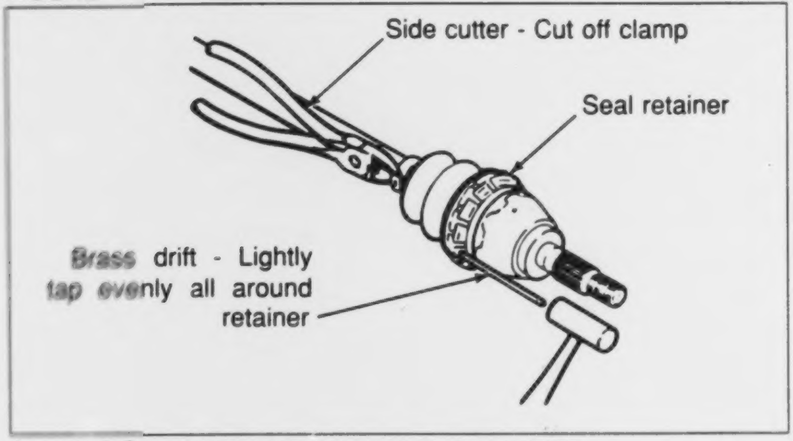
CAUTION

Be careful not to bend or dent the half shaft.

3. Put a piece of masking tape on the half shaft at the small end of the old boot to aid in positioning the new boot correctly.

4. Use side cutting pliers to cut off the clamp at the small end of the boot. (Figure 1)

FIGURE 1


Side cutter - Cut off clamp
Seal retainer
Brass drift - Lightly tap evenly all around retainer

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5. Cut the clamp off the large end of the boot or if there is a boot retainer, tap around the edges of the boot retainer with a hammer and a brass drift until it comes loose. (Figure 1)

6. Slip the boot off the axle.

7. Use shop towels to remove as much grease as possible from the C-V joint.

8. Examine the grease carefully for dirt, moisture, or other signs of contamination.

9. Examine the C-V joint and replace it if necessary. (See Job Sheet 4.)

10. Slip the new boot, clamp, and boot retainer (if used) onto the half shaft in the correct order and position and move them back out of the way.

11. Assemble the joint on the shaft and pack it with grease according to manufacturer's instructions.

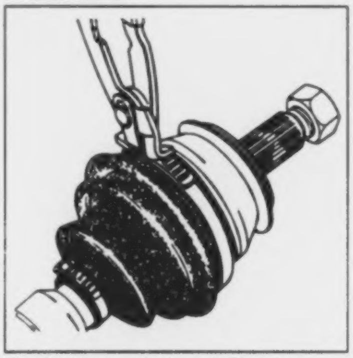
12. Put the remainder of the grease in the boot as suggested by the manufacturer.

13. If a clamp is used to secure the boot to the joint, use a special crimping tool to secure the clamp as recommended. (Figure 2)

14. If the boot uses a boot retainer, move the new boot and boot retainer into position on the joint's outer race.

15. Position the axle with the half shaft down and the joint up on an arbor press and use your hands to position the joint on the boot and retainer.

FIGURE 2



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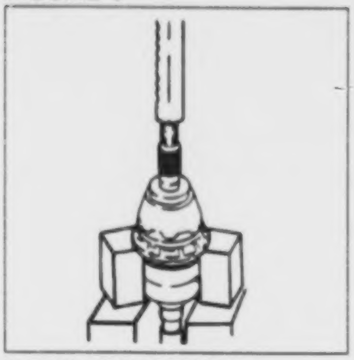
16. Press the boot and boot retainer onto the joint with the arbor press. (Figure 3)

17. Position the shaft end of the boot correctly in its grooves even with the masking tape.

18. Install the clamp.

FIGURE 3



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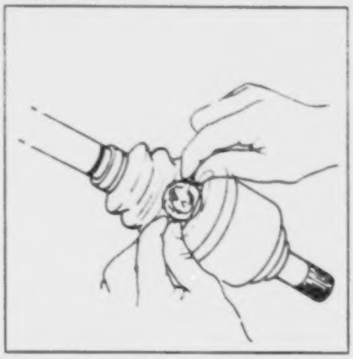
19. If the folds of the boot have a kink or dimple, pull gently on either side of the rubber to remove it. (Figure 4)

20. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

FIGURE 4



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JOB SHEET 4

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 7D

Remove, inspect, and replace front drive axle joints.

INTRODUCTION

Front drive axle joints do not normally require inspection or service. These joints are generously packed in joint grease and sealed inside their boots for the life of the joint. However, if the boot becomes damaged and the joint grease contaminated, the joint may quickly be damaged. Problems with power train mounts or transaxle components can result in drive axle misalignment and cause drive axle joint damage. Road damage can also cause joint problems.

If the technician suspects that the front drive axle joints are damaged, these joints must be removed from the vehicle and inspected to confirm the diagnosis. When damage is present, the joint can be repaired or replaced. Replacement kits are available to completely replace all parts of a C-V joint. The repair kit for a Rzeppa joint contains a new cage and balls; the inner race and outer housing is re-used. The repair kit for a tripod joint contains a new spider, balls, and needle bearings; the outer housing of the joint is re-used. The following job sheet gives the procedures for removing, inspecting, and replacing the two most common types of front drive axle joints—the Rzeppa and the tripod.

EQUIPMENT AND MATERIALS

- Front drive axle with a Rzeppa outboard joint and a tripod inboard joint
- Appropriate service manual
- Bench vise
- Snap-ring pliers
- Plastic-faced mallet
- Shop towels
- Brass drift
- Hammer
- Dull screwdriver
- Permanent marker
- Approved cleaning solvent
- Rzeppa joint repair kit
- Masking tape or spider bearing retainer
- Tripod joint repair kit

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The front drive axle should be removed from the vehicle. (Job Sheet 2)

PROCEDURE

Remove, inspect, and replace a Rzeppa joint

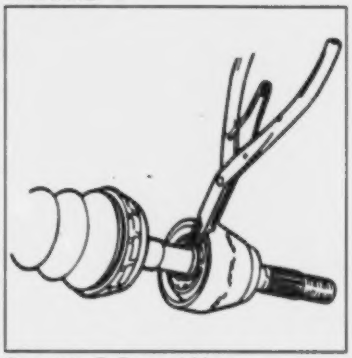
1. Secure the half shaft in a bench vise so that neither end of the drive axle is hanging from its C-V joint.

CAUTION

Be careful not to bend or dent the half shaft.

2. Remove the boot from the joint. (See Job Sheet 3.)
3. Check the appropriate service manual to see how the joint is secured to the half shaft.
4. If the joint is secured by a race retaining ring, use snap-ring pliers to remove the ring from the half shaft. (Figure 1)

FIGURE 1



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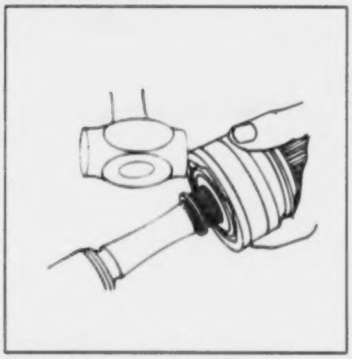
5. If the joint is secured by a circlip, tap gently around the joint's outer housing with a plastic-faced mallet to separate the outer housing from the half shaft. (Figure 2)
6. Separate the outer housing from the half shaft.
7. Use shop towels to remove as much grease as possible from the joint.

FIGURE 2



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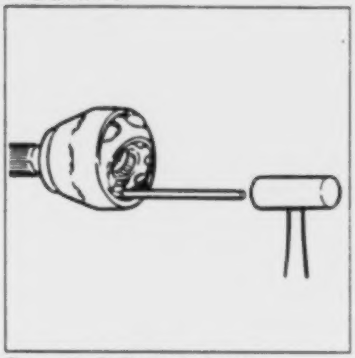
8. Examine the grease carefully for dirt, moisture, or other signs of contamination.

9. Use a brass drift and a hammer to tap gently on one side of the cage, tilting the cage so each ball can be removed. (Figure 3)

FIGURE 3



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CAUTION

Be very careful. It is extremely easy to distort or damage the cage or inner race during this procedure.

10. Use a permanent marker to make an arrow above the window on the cage where you remove the first ball. The arrow should point in the direction in which you will remove the next ball.

CAUTION

The balls in a Rzeppa joint are precision-sized to their position in the joint and cannot be used in another position. It is important that they be replaced in their exact position.

11. Fold a shop towel to make a narrow trough in which to store the balls from the joint.

12. Use a dull screwdriver to pry the ball out of the cage, placing the ball to the far left in the trough.

13. Tilt the cage to expose the next window in the cage, moving in the direction of the arrow.

14. Remove the next ball and repeat these steps until all the balls are removed.

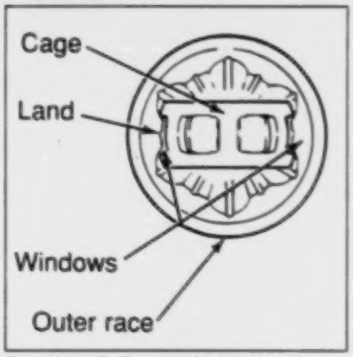
15. Place the balls from left to right in the trough in the shop towel *in the order in which they were removed.*

16. Rotate the cage and inner race 90° and align the windows on either side of the cage with the lands in the outer race. (Figure 4)

17. Pull the cage and inner race out of the outer housing.

    NOTE: You may have to use a screwdriver to gently pry the cage out.

FIGURE 4



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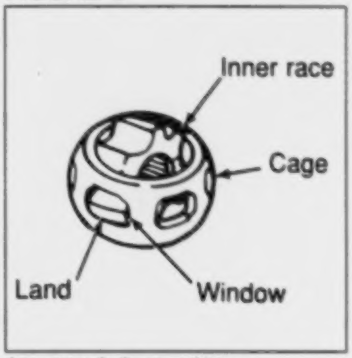
18. Rotate the inner race 90° and remove it from the cage. (Figure 5)

19. Clean all parts in an approved cleaning solvent and inspect them thoroughly.

20. Examine the inside of the outer housing for grooves worn in the race.

    NOTE: This is the most common kind of damage in a Rzeppa joint.

FIGURE 5



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21. Check the inner race for grooves and other damage.

22. Look for distortion or damage to the cage.

23. Inspect the balls for gouges, grooves, or other damage.

    CAUTION

    Make sure you keep the balls in the correct order.

24. If there is any damage to the balls and cage, use a repair kit and replace these parts.

25. If the inner and/or outer races are damaged, replace the entire joint.

26. Clean and inspect the half shaft before replacing the joint.

27. Make sure the new boot and boot clamps are on the half shaft before installing the new joint.

28. Coat the parts lightly with the specified joint grease before beginning assembly.

29. Put the inner race inside the cage and rotate it 90°.

30. Put the inner race and the cage inside the outer housing and rotate it 90°.

CAUTION

If the joint uses a retainer ring, the side of the cage where the retainer ring is installed should face the outside.

31. Use a brass drift and a hammer to tilt the cage so that you can install the first ball.

NOTE: If you are installing the original balls, expose the window with the arrow over it and install the first ball on the left side of the trough. Proceed in the direction of the arrow, always installing the ball that is on the left. Unlike original parts, the balls in a repair kit can be installed at any location inside the cage.

32. Repeat the above step, installing all the balls.

33. Install a new circlip or race retainer ring as directed by the instructions with the kit.

34. Slide the joint on the half shaft and press to seat the retainer ring or circlip.

35. Hold the joint in a straight line with the half shaft in one hand and the spindle shaft in the other and attempt to twist the joint.

36. If you can twist the joint at all, it is too loose, and the entire joint must be replaced.

NOTE: This looseness is caused by excessive wear in the inner and/or the outer race.

37. Pack the joint with the recommended amount of joint grease.

38. Install the boot. (Job Sheet 3)

39. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Remove, inspect, and replace a tripod joint

1. Secure the half shaft in a bench vise with the joint end up.

   CAUTION

   Be careful not to bend or dent the half shaft.

2. Remove the boot from the joint. (See Job Sheet 3.)

3. Check the appropriate service manual to see how the joint is secured in the outer housing.

   NOTE: Tripod joints are secured in their housing in several different ways. Special tabs or retaining rings may secure the tripod spider inside the housing.

4. Follow the service manual's instructions in removing the joint from the housing.

5. If the joint may be reinstalled or repaired instead of replaced, make matchmarks on the tripod housing, the spider, and the half shaft so the joint can be reassembled in the same position.

6. Hold the three balls (or wheels) in place on the spider as you slide the spider out of the housing.

   CAUTION

   If the balls are not held in place, the balls and the needle bearings inside them may fall out.

7. Use shop towels to remove as much grease as possible from the joint.

8. Examine the grease carefully for dirt, moisture, or other signs of contamination.

9. Rotate the balls on their needle bearings to make sure they rotate smoothly.

10. Use a permanent marker to number the three trunnions on the spider.

    CAUTION

    Each ball and needle bearings must be replaced on the same trunnion.

11. Remove each ball and its needle bearings and keeping them together, set them aside on the workbench with the parts from #1 trunnion to the left and the parts from #2 and then #3 to the right.

12. Clean all parts in an approved cleaning solvent and inspect them thoroughly.

13. Examine the inside of the outer housing for grooves worn in the race.

14. Inspect the spider for grooves, wear, or damage.

15. Check the balls and needle bearings for damage and wear.

16. If the spider, balls, and/or needle bearings are damaged, replace them with a replacement kit.

17. If the outer housing is damaged, replace the entire joint.

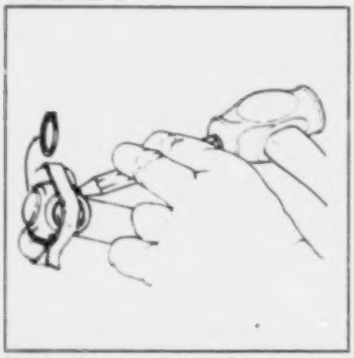
18. Use a plastic-faced mallet or a brass drift and a hammer to tap the spider away from the end of the half shaft so you can remove the snap ring.

NOTE: If you must remove or replace the spider from the half shaft while the balls are still on the trunnions, install a spider bearing retainer or wrap the three balls with masking tape to hold them on the spider. (Figure 6)

19. Use snap ring pliers to remove the snap ring.

20. Tap the spider off the half shaft with a plastic-faced mallet or a hammer and a brass drift. (Figure 6)

FIGURE 6



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21. Clean and inspect the half shaft before replacing the joint.

22. Make sure the new boot and boot clamps are on the half shaft before installing the new joint.

23. Tap the new spider onto the half shaft past the area where the snap ring should be installed.

24. Install the snap ring in its groove and tap the spider forward.

25. Coat the parts lightly with the specified joint grease before beginning assembly.

26. Replace the balls and needle bearings on the trunnions if appropriate.

CAUTION

If you replace the old balls and needle bearings, make sure they are installed on the correct trunnion.

27. Install the spider and balls in the outer housing of the joint as directed by the service manual or repair kit.

28. Pack the joint with the recommended amount of joint grease.

29. Install the boot. (Job Sheet 3)

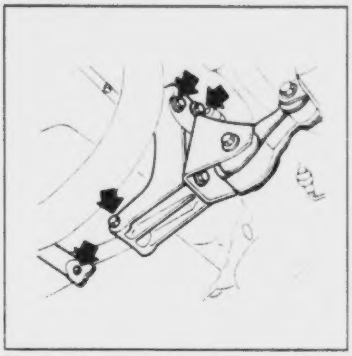
30. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

OBJECTIVE 7E **Inspect, remove, and replace transaxle power train mounts.**

INTRODUCTION

FIGURE 1



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Because the engine, the clutch, the transaxle, and the drive axles function together so closely, the alignment of any one of these components will affect the others. In a vehicle using a transaxle, the transaxle power train mounts include all mounts which secure any of these components to the chassis. The condition of the power train mounts is important to the correct alignment and functioning of all these components. A typical power train mount is shown in Figure 1. Proper diagnosis of transaxle problems always includes checking the power train mounts.

The number, design, and location of the power train mounts varies from vehicle to vehicle, and no standard procedure can be given that will cover their inspection, removal, and replacement. Consult the appropriate service manual for this specific information. The following general guidelines will give you some hints.

Guidelines

- Raise the vehicle and pull up and push down on the transaxle while you look at each mount:
  - If there is movement between the mount and its attaching point on the chassis, tighten the attaching bolts to the appropriate torque.
  - If the rubber separates from the metal part of the mount, replace the mount.
  - If the transaxle will move up but not down, replace the mount.

- Always disconnect the negative battery cable and any electrical connections or accessories located around the mount before replacing a mount. Move these out of the way before continuing, labeling wires you disconnect for easier reassembly.
- If a mount must be replaced, install an engine support fixture or attach the engine to a hoist as directed by the vehicle service manual. Lift the engine just enough to take the weight of the engine off the mounts so they can be replaced.
- When installing a new mount, first attach the mount to the chassis and torque the bolts to the required specifications. Then attach and torque the bolts which connect the mount to the appropriate part of the power train.
- Some manufacturers use special alignment bolts which check the alignment of the power train before the bolts connecting the mount to the power train component are torqued.
- If the manufacturer does not have a recommended procedure for aligning power train mounts, follow these steps:

    1. Install the mounts to the chassis, torquing the bolts to specifications.
    2. Install the mounts to the appropriate power train components, leaving the bolts slightly loose.
    3. Reconnect the battery and electrical connections necessary to start the engine.
    4. Brace the front wheels and start the engine.
    5. Shift into first gear.
    6. Release the clutch and accelerate slightly for only a second.
       NOTE: This will settle the power train mounts into alignment.
    7. Depress the clutch and turn off the engine.
    8. Disconnect the negative battery cable.
    9. Torque the loose bolts to specifications.

EQUIPMENT AND MATERIALS

- Vehicle with a manual transaxle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 7F

Remove a transaxle assembly.

INTRODUCTION

If diagnosis shows that transaxle components must be repaired or replaced, the transaxle will probably have to be removed. Because of the many types of transaxles and the different positions where they may be found in the vehicle, there are a variety of ways to remove a transaxle.

Some transaxle housings have a covered access opening to the transmission and/or the differential section of the transaxle. (Figure 1) You may be able to remove some or all necessary parts through such an opening and avoid removing the entire transaxle.

Other transaxles can be removed while the engine remains in the vehicle. In these cases, the transaxle may be attached to a removable subframe or cradle bolted to the chassis. (Figure 2)

FIGURE 1

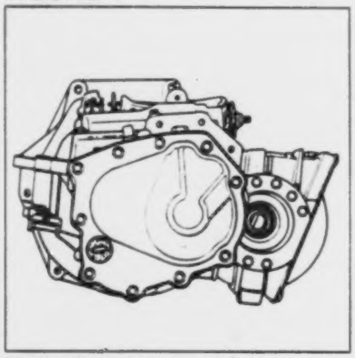

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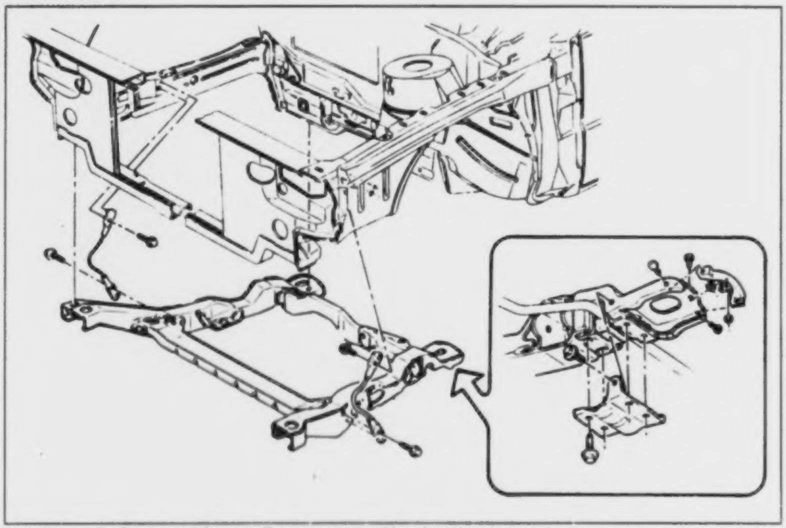
FIGURE 2



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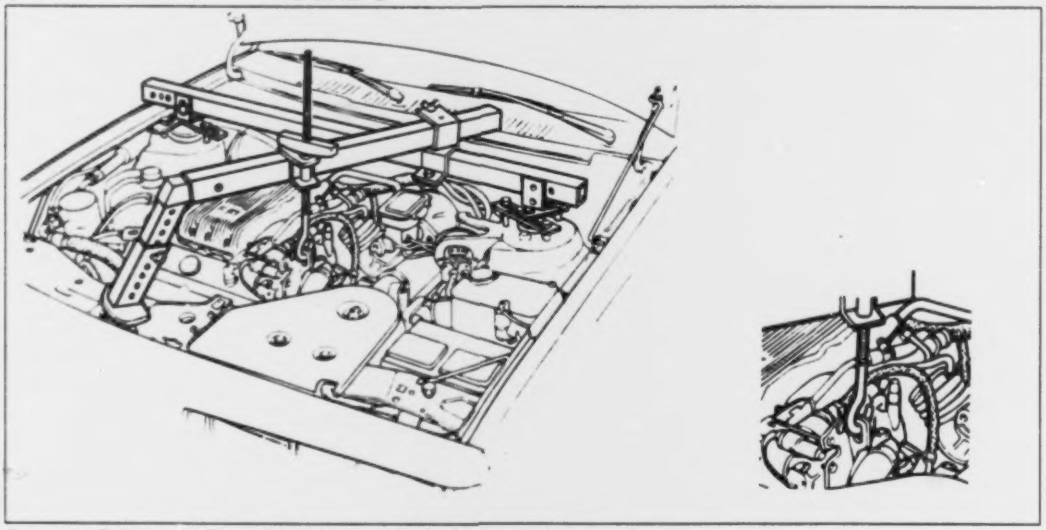
The engine is often held in the vehicle by an engine support fixture while the transaxle is removed. (Figure 3)

FIGURE 3



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In other vehicles, both the engine and the transaxle must be removed—either as a unit or one at a time. Some transaxles are removed through the top of the engine compartment and others are removed from the bottom.

Although you must consult the vehicle's service manual for specific procedures for removing a transaxle, the following guidelines may provide some helpful hints:

Guidelines

- Identify any special tools you need before you begin removal. The vehicle service manuals will provide a list of such tools.
- Be sure the engine and transaxle are cool enough to work on before you begin.
- Always disconnect the negative battery cable before you do any other work in the engine compartment.
- Use fender covers if you are working under the hood.
- Drain the transaxle fluid before you remove the transaxle.
- If the engine must be removed, drain the radiator, coolant, and engine oil.

- If the engine and/or transaxle is removed through the top of the engine compartment, always remove the hood—even if the service manual does not mention this as a requirement. Mask the edges of the hood before removal so you don't scratch the paint. Place matchmarks on the chassis and the hood hinge brackets so you can realign the hood properly when you replace it. Set the hood back on the engine compartment after the engine is removed but don't reinstall the bolts. This will protect the hood from accidental damage until you are ready to replace the engine.

◆ WARNING ◆

Neither an engine support fixture nor a transmission jack is designed to hold the weight of the engine and the transaxle *at the same time*. Other hoists, jacks, or supports must be used if this is necessary.

- Transaxle housings are made of aluminum and scratch easily. Do not pry the transaxle and the clutch housing or any other mating surfaces apart with a screwdriver or pry bar. Any scratch on a mating surface can cause a lubricant leak later.
- If two mating surfaces do not release from each other easily, use a plastic mallet to break the hold of the sealant.
- Use masking tape and a pen to label all wires, hoses, and straps so they can be replaced properly.
- Tag all nuts, bolts, and screws and keep them separated.
- Brush or scrape dirt and grease from the transaxle and clutch housings and the mating area on the engine block. Use a steam cleaner or approved degreaser or cleaning solvent to clean the housings thoroughly before beginning disassembly. Use compressed air to dry the parts.
- It is always cost-effective to check the condition of the clutch while the transaxle is removed.

EQUIPMENT AND MATERIALS

- Vehicle with a manual transaxle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB
SHEET 7

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 7G

Remove, inspect, and replace transaxle shift assembly components located inside the transaxle housing.

INTRODUCTION

Although the shift forks on transaxles operate on shift rails inside the housing, no standard design is used. The appropriate service manual must be used to remove, inspect, and replace this assembly.

Shift assemblies ordinarily contain many small parts. Pay close attention to the service manual diagrams which show how these parts fit together. All parts except seals can be cleaned in an approved cleaning solvent and blown dry with compressed air before inspection. Use the Guidelines for removing, inspecting, and replacing transmission internal shift components found in Job Sheet 5, Unit 4, *Service Manual Transmissions*, to help you with many of the tasks in this job sheet. Check shift rods and forks for wear much as you would check components in a transmission. A shift assembly that is worn, damaged, or not assembled correctly can cause the transaxle to jump out of gear.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheet 5, Unit 4***
- Other equipment and material as required by procedure

The transaxle should be removed from the vehicle. (Job Sheet 6)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 8

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

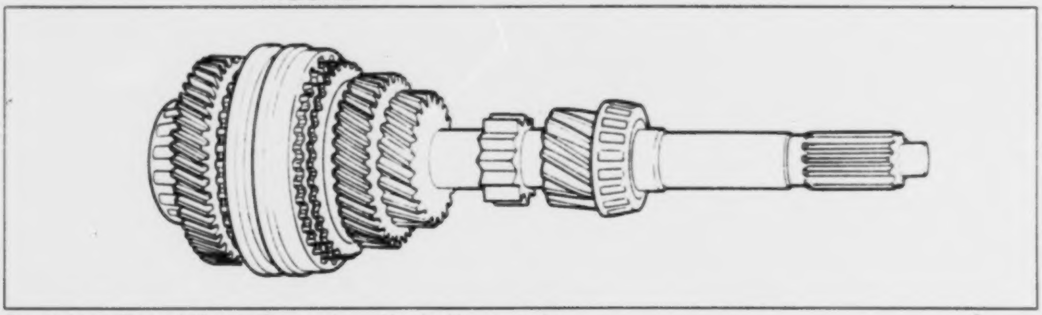
OBJECTIVE 7H

Remove, inspect, and replace input shaft assembly components.

INTRODUCTION

The design of an input shaft on a transaxle is different from the design of a transmission's input shaft. Because it may contain cluster gears, speed gears, and synchronizers, a transaxle's input shaft is more like a transmission countershaft or output shaft. (Figure 1)

FIGURE 1



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Although the possible components on a transaxle input shaft are familiar—bearings, bushings, synchronizers, cluster gears, speed gears, snap rings, washers—the number and type of components, their arrangement on the shaft, and how the shaft itself is removed from the housing vary from transaxle to transaxle. This makes it impossible to give a standard procedure for removing, inspecting, and replacing input shaft assembly components.

End play on a transaxle input shaft should always be checked both before removing the shaft and upon replacing it in the housing. (See Job Sheet 11.) The information learned from checking the end play is very important in diagnosing transaxle problems. Use the vehicle's service manual and the Guidelines from Unit 4, *Service Manual Transmissions*, for input shafts (Job Sheet 6), output shafts (Job Sheet 7), and synchronizers (Job Sheet 8) to help you complete this job sheet. You will find that once you learn a procedure such as removing a synchronizer assembly, the removal is the same whether you remove it from a transaxle input shaft or a transmission output shaft.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheet 6, 7, and 8, Unit 4***
- Other equipment and material as required by procedure

The transaxle should be removed from the vehicle. (Job Sheet 6)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

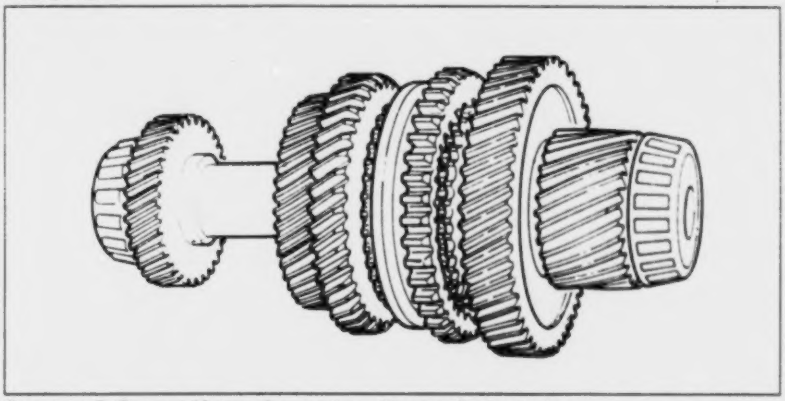
OBJECTIVE 7I

Remove, inspect, and replace output shaft assembly components.

INTRODUCTION

The output shaft on a transaxle not only contains speed gears and synchronizers, it also contains the ***output shaft drive gear*** which drives the ring gear for the differential section of the transaxle. This drive gear, located at the end of the output shaft nearest the differential section, is often machined directly on the output shaft itself. (Figure 1)

FIGURE 1



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Because of the importance of obtaining a proper mesh between the output shaft drive gear and the ring gear, you should always make a ring gear tooth contact pattern test and check ring gear backlash whenever you reinstall the output shaft in the transaxle. As on the input shaft, the end play on the transaxle output shaft should be checked both before removing the shaft and upon replacing it in the housing. (See Job Sheet 11.)

Use the vehicle's service manual and the Guidelines from Unit 4, *Service Manual Transmissions*, for input shafts (Job Sheet 6), output shafts (Job Sheet 7), and synchronizers (Job Sheet 8) to help you complete this job sheet.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheets 6, 7, and 8, Unit 4***
- Other equipment and material as required by procedure

The transaxle should be removed from the vehicle. (Job Sheet 6)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

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JOB
SHEET 10

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 7J

Remove, inspect, and replace reverse idler gear assembly components.

INTRODUCTION

The reverse idler gear assembly on almost all transaxles is a sliding gear. Because there is no synchronizer, it may be harder to shift into reverse gear on a vehicle with a transaxle, and the gear may clash when shifted. Other components on the reverse idler gear assembly in a transaxle are very similar to those found in a transmission. Use the appropriate service manual and the Guidelines from Unit 4, *Service Manual Transmissions*, for reverse idler gear assemblies (Job Sheet 10) to assist you with this job sheet.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheet 10, Unit 4***
- Other equipment and material as required by procedure

The transaxle should be removed from the vehicle. (Job Sheet 6)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 7K

Measure and adjust end play and preload on transaxle shafts.

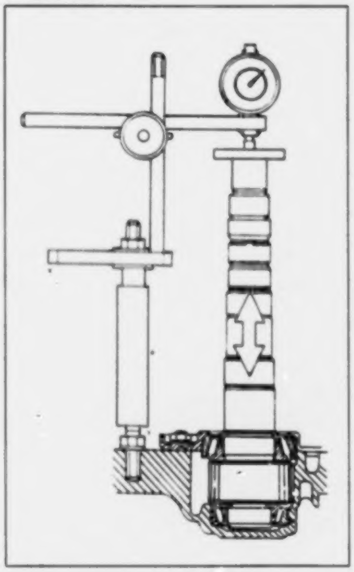
INTRODUCTION

The ***end play*** on each transaxle shaft must be exact to maintain the proper mesh between the gears. However, making sure the gears on the various shafts mesh correctly can be more difficult in a transaxle than in a transmission. To save space, transaxle speed gears are often narrower than transmission gears. There are very often synchronizers and speed gears on both shafts instead of just on the output shaft as is usual in a transmission. Sometimes, there is one or more **intermediate shafts** on a transaxle in addition to the input shaft, output shaft, and reverse idler gear shaft.

Because the shafts in a transaxle usually ride on rollers, tapered rollers, or ball bearings, it is also important to make sure each shaft is operating under the correct ***preload***. Each type and size of bearing is designed to operate under a certain type of load. Adjusting the shaft's preload makes sure that these bearings have the proper operating conditions, reducing the chance of bearing failure.

End play and preload on transaxle shafts is measured using either feeler gauges, dial indicators, depth micrometers, or special depth gauges similar to those used for measuring drive pinion gear depth. (Figure 1) Shaft end play and preload is normally checked before the transaxle is disassembled and again as the transaxle is being reassembled. Knowing whether these measurements are within specifications before the individual parts are removed from the shaft gives the specialist important information for making an accurate diagnosis of transaxle problems.

FIGURE 1



Used with permission of Chrysler Corporation.

Once measurements are made, end play and preload are normally adjusted by using different sizes of thrust washers, shims, or spacers. When and how end play and preload are measured on each shaft, and where the washers, shims, or spacers are placed to make the appropriate corrections varies from model to model. No standard procedure can be given which will be useful for most vehicles. Follow the instructions in the appropriate service manual.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- Other equipment and material as required by procedure

The transaxle should be removed from the vehicle. (Job Sheet 6)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

OBJECTIVE 7L

Remove, inspect, adjust, and replace the transaxle differential section.

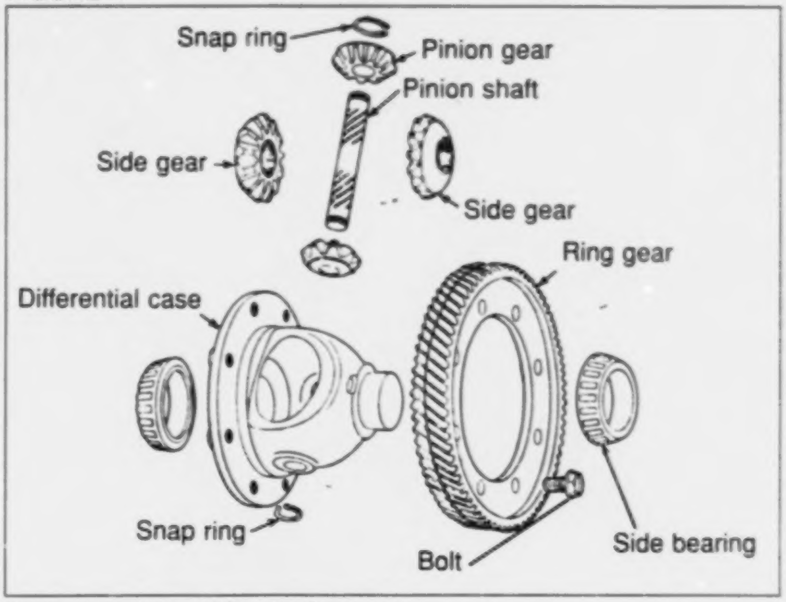
INTRODUCTION

The differential section of a transaxle is usually considered separately from the transmission section when performance problems are diagnosed and when the transaxle is disassembled. If a problem is clearly traced to the transmission section, the differential section, although it will need to be removed, may not need to be disassembled at all. The reverse is also true—sometimes the differential section is the source of transaxle problems, and the transmission section is not disassembled.

NOTE: Even if the differential section is not disassembled, you should clean and inspect the differential assembly, particularly the bearings, when the transaxle is removed. Ring gear backlash should also be checked whenever the two sections are removed.

The differential section of a transaxle (Figure 1) is almost identical to a separate differential found in a front-engine, rear-wheel drive vehicle. The major difference is that the ring gear on a transaxle is driven by the output shaft drive gear and in a differential, the ring gear is driven by the drive pinion assembly. There may be other differences as well, depending upon the transaxle design.

FIGURE 1



Used with permission of Chrysler Corporation.

Most procedures involved in removing, inspecting, adjusting, and replacing the differential section of a transaxle are identical to many of the procedures in Unit 2, *Servicing Differentials and Rear Drive Axles*. However, you must check the vehicle's service manual carefully: many procedures may involve small but important variations.

All the procedures on the following job sheets in Unit 2, *Service Differentials and Rear Drive Axles*, will need to be done to complete this job sheet:

- Measure ring gear runout. (Job Sheet 3)
- Check ring gear tooth contact patterns. (Job Sheet 4)
- Measure and adjust side bearing preload and ring to pinion gear backlash. (Job Sheet 5)
- Remove the differential case assembly and clean and inspect the differential housing. (Job Sheet 7)
- Remove, inspect, and replace ring gear. (Job Sheet 8)
- Measure differential case runout. (Job Sheet 9)
- Remove, inspect, and replace differential side bearings. (Job Sheet 10)
- Remove, inspect, measure, adjust, and replace the parts of a conventional differential case assembly. (Job Sheet 11)

  NOTE: If you replace the ring gear on a transaxle, always replace the output shaft drive gear. The reverse, however, is not true—unless the ring gear is damaged, it does not need to be replaced when the output shaft drive gear is replaced.

- Replace and adjust the differential case assembly. (Job Sheet 16)

Use these job sheets and the vehicle's service manual to remove, inspect, adjust, and replace the transaxle differential assembly.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Job Sheets 3, 4, 5, 7, 8, 9, 10, 11, and 16, Unit 2***
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

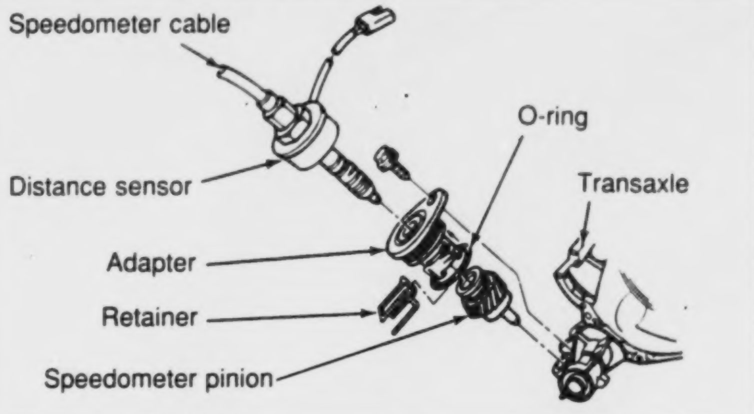
OBJECTIVE 7M

Remove, inspect, and replace the speedometer drive assembly.

INTRODUCTION

A speedometer drive assembly on a transaxle may be either a PM (permanent magnet) generator, a more traditional gear assembly, or an electronic speed sensor. Speedometer assemblies which use an electronic sensor are rapidly becoming the most common. In any case, the type and design will depend upon the individual manufacturer. The following is a typical PM generator assembly: (Figure 1)

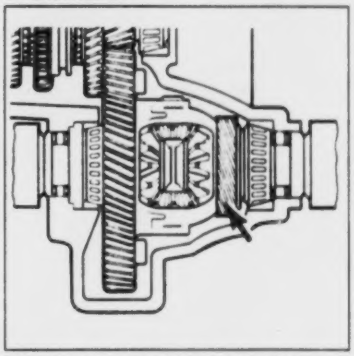
FIGURE 1



Used with permission of Chrysler Corporation.

A speedometer drive assembly can be installed in any one of a several locations. In a transmission, the speedometer assembly is almost always installed at the rear of the output shaft. In a transaxle, it may be installed on one of the transmission section gear shafts, but it is sometimes installed on the differential case in the differential section of the transaxle. (Figure 2) Speedometer drive assemblies in transaxles are also sometimes installed on the drive axle itself or even on the wheel hub.

FIGURE 2



Used with permission of Ford Motor Company.

Use the appropriate service manual to help you remove, inspect, and replace the speedometer drive assembly.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 14

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

OBJECTIVE 7N

Clean and inspect the transaxle housing and transaxle housing components.

INTRODUCTION

Cleaning and inspecting the transaxle housing and transaxle housing components is very similar to cleaning and inspecting a transmission. Because the use of a transaxle is often part of a general effort by the manufacturer to reduce fuel consumption, transaxles are almost always made of aluminum. Aluminum housings require additional care to avoid scratches and gouges since this metal is softer than cast iron used in some transmissions. Manufacturers also make transaxle housings light weight by making them with thinner walls. For this reason, they are more susceptible to vibrations and may have more warping and cracking.

A transaxle is installed so close to the engine that it is sometimes difficult to tell whether a leak is from the engine or the transaxle. Transaxles frequently have more leaks where bearings hold shafts in place and from access covers and transaxle housings which divide into several parts. Because there are usually more gear shafts in a transaxle, there are also more bushings which require special inspection for wear.

Use the appropriate service manual and the Guidelines for cleaning and inspecting transmission housings and transmission housing components in Job Sheet 12, Unit 4, *Service Manual Transmissions* to help complete this job sheet.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheet 12, Unit 4***
- Other equipment and material as required by procedure

The transaxle should be removed from the vehicle. (Job Sheet 6)

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 15

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 70

Assemble a transaxle.

INTRODUCTION

Assembling a transaxle, like assembling a transmission, is usually the reverse of the disassembly process. Because the parts of a transaxle assembly are normally installed so close together, the measurement of all gears, shafts, bearings, and other critical parts becomes particularly important. During reassembly, be sure to make all recommended measurements including shaft end play and preload as discussed in Job Sheet 11.

Use the guidelines for assembling a transmission from Job Sheet 13, Unit 4, *Service Manual Transmissions*, and the appropriate service manual to complete this job sheet.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheet 13, Unit 4***
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 16

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

OBJECTIVE 7P

Install a transaxle and complete transaxle service.

INTRODUCTION

Reinstalling the transaxle in the vehicle is the reverse of removal (Job Sheet 6) and can be complicated by the fact that the engine as well as the transaxle may have been removed. It is very important that the instructions in the service manual be followed carefully.

If the service manual does not give a recommended method for adjusting the position of the transaxle in the transaxle mounts upon re-installation, use the method given in Job Sheet 5. The proper alignment of the power train components depends upon this adjustment. Poor alignment results in poor performance, vibration, noise, and damage.

Some transaxles use the same lubricant as the engine; however, most use their own lubricant. Most commonly a lightweight oil is used which absorbs less energy and allows better gas mileage. Be sure to use the correct type and amount of lubricant for the vehicle, or damage can result. Lubricant is normally filled to the bottom edge of the transaxle filler plug. Some transaxles have a visual gauge or a dipstick to allow you to check fluid level.

Use the appropriate service manual and the Guidelines for completing transmission service in Job Sheet 13, Unit 4, *Service Manual Transmissions*, to help you complete this job sheet.

EQUIPMENT AND MATERIALS

- Manual transaxle
- Appropriate service manual
- ***Guidelines, Job Sheet 13, Unit 4***
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

JOB SHEET 1

Inspect, adjust, and replace transaxle shift linkage components located outside the transaxle housing.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle correctly.	_____	_____
3. Inspected and replaced shift linkage parts according to steps outlined in the appropriate service manual.	_____	_____
4. Adjusted and lubricated the shift linkage parts using recommended service manual procedures.	_____	_____
5. Tested the shift linkage adjustment correctly.	_____	_____
6. Followed the applicable guidelines from Job Sheets 1 and 2, Unit 4.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 2 **Remove and replace front drive axles.**

STUDENT'S NAME ____________________ DATE ________________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION **Evaluator Note:** Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly raised and prepared the vehicle.	_____	_____
3. Removed the front drive axles following the appropriate service manual.	_____	_____
4. Replaced the front drive axles following the procedures recommended in the service manual.	_____	_____
5. Followed the guidelines recommended in the job sheet.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS ____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 3

Inspect, remove, and replace front drive axle boots.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
3. Properly prepared the vehicle.	_____	_____
4. Inspected the boots correctly.	_____	_____
5. Removed and replaced the boot following procedures outlined in the job sheet and the boot replacement kit.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 4 **Remove, inspect, and replace front drive axle joints.**

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION **Evaluator Note:** Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Raised and prepared the vehicle correctly.	_____	_____
3. Used the appropriate service manual as a reference throughout the job sheet procedure.	_____	_____
4. Removed and inspected a Rzeppa joint following procedures outlined in the job sheet.	_____	_____
5. Replaced a Rzeppa joint following job sheet procedures and the instructions in the joint replacement kit.	_____	_____
6. Removed and inspected a tripod joint following procedures outlined in the job sheet.	_____	_____
7. Replaced a tripod joint following job sheet procedures and the instructions in the joint replacement kit.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

JOB SHEET 5

Inspect, remove, and replace transaxle power train mounts.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected the transaxle power train mounts following the appropriate service manual.	_____	_____
3. Removed the transaxle power train mounts following the procedures outlined in the service manual.	_____	_____
4. Replaced and adjusted the transaxle power train mounts following the service manual recommendations.	_____	_____
5. Followed the guidelines recommended in the job sheet.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.

3 — Moderately skilled — Has performed job during training program; limited additional training may be required.

2 — Limited skill — Has performed job during training program; additional training is required to develop skill.

1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 6

Remove a transaxle assembly.

STUDENT'S NAME ______________ DATE __________

EVALUATOR'S NAME ______________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly prepared the vehicle.	____	____
3. Removed the transaxle assembly following procedures in the appropriate service manual.	____	____
4. Followed the guidelines recommended in the job sheet.	____	____
5. Observed safety rules and precautions.	____	____
6. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

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907

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

JOB SHEET 7

Remove, inspect, and replace transaxle shift assembly components located inside the transaxle housing.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly prepared the transaxle.	____	____
3. Removed the transaxle shift assembly components following the appropriate service manual.	____	____
4. Inspected the transaxle shift assembly components following the appropriate recommendations.	____	____
5. Replaced the transaxle shift assembly components following the procedures outlined in the service manual.	____	____
6. Followed the applicable guidelines from Job Sheet 5, Unit 4.	____	____
7. Observed safety rules and precautions.	____	____
8. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

JOB SHEET 8

Remove, inspect, and replace input shaft assembly components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transaxle.	_____	_____
3. Removed, inspected, and replaced the input shaft assembly components following the appropriate service manual.	_____	_____
4. Followed the applicable guidelines from Job Sheets 6, 7, and 8, Unit 4.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 9

Remove, inspect, and replace output shaft assembly components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transaxle.	_____	_____
3. Removed, inspected, and replaced the output shaft assembly components following procedures given in the appropriate service manual.	_____	_____
4. Followed the applicable guidelines from Job Sheets 6, 7, and 8, Unit 4.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 10

Remove, inspect, and replace reverse idler gear assembly components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the transaxle.	_____	_____
3. Removed, inspected, and replaced the reverse idler gear assembly components following procedures in the appropriate service manual.	_____	_____
4. Followed the applicable guidelines from Job Sheets 10, Unit 4.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 11

Measure and adjust end play and preload on transaxle shafts.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared the vehicle.	_____	_____
3. Measured end play on the transaxle shafts according to the procedures in the appropriate service manual.	_____	_____
4. Measured preload on the transaxle shafts following the recommended procedures in the service manual.	_____	_____
5. Adjusted end play on the transaxle shafts according to the procedures in the appropriate service manual.	_____	_____
6. Adjusted preload on the transaxle shafts following the appropriate recommended procedures.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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917

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

918

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 12

Remove, inspect, adjust, and replace the transaxle differential section.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle properly.	_____	_____
3. Used the appropriate service manual as the primary resource for the procedures in this job sheet.	_____	_____
4. Used Job Sheets 3, 4, 5, 7, 8, 9, 10, 11, and 16 from Unit 2, as references throughout the job sheet procedure.	_____	_____
5. Measured ring gear runout correctly.	_____	_____
6. Checked and evaluated ring gear tooth contact patterns accurately.	_____	_____
7. Measured and adjusted side bearing preload and ring to drive gear backlash according to procedures outlined in the appropriate service manual.	_____	_____
8. Removed the differential case assembly and cleaned and inspected the differential housing according to outlined procedures.	_____	_____

The student:	YES	NO
9. Removed, inspected, and replaced the ring gear correctly.		
10. Measured differential case runout correctly.		
11. Removed, inspected, and replaced the differential side bearings according to recommended procedures.		
12. Removed, inspected, measured, adjusted, and replaced the parts of the differential case assembly correctly.		
13. Replaced and adjusted the differential case assembly according to outlined procedures.		
14. Observed safety rules and precautions.		
15. Cleaned work area and returned equipment and materials to proper storage.		

EVALUATOR'S COMMENTS ______________________________

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 13

Remove, inspect, and replace the speedometer drive assembly.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed the speedometer drive assembly following procedures given in the appropriate service manual.	_____	_____
3. Inspected the speedometer drive assembly correctly.	_____	_____
4. Replaced the speedometer drive assembly according to directions in the service manual.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES V

JOB SHEET 14

Clean and inspect the transaxle housing and transaxle housing components.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Cleaned the transaxle housing and transaxle housing components following the appropriate service manual.	____	____
3. Inspected the transaxle housing and transaxle housing components correctly.	____	____
4. Followed the applicable guidelines from Job Sheet 12, Unit 4.	____	____
5. Observed safety rules and precautions.	____	____
6. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

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AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

JOB SHEET 15

Assemble a transaxle.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Assembled the transaxle following the procedures given in the appropriate service manual.	_____	_____
3. Followed the applicable guideline from Job Sheet 13, Unit 4.	_____	_____
4. Observed safety rules and precautions.	_____	_____
5. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

V

JOB SHEET 16

Install a transaxle and complete transaxle service.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	Yes	No
1. Obtained proper equipment and materials.	_____	_____
2. Installed the transaxle following the appropriate service manual.	_____	_____
3. Adjusted the transaxle mounts as recommended by the service manual or following the method given in Job Sheet 5.	_____	_____
4. Completed transaxle service as recommended in the service manual.	_____	_____
5. Followed the applicable guidelines from Job Sheet 13, Unit 4.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES

NAME ______________________________ SCORE ________

OBJECTIVE 1

Choose the correct definitions for terms associated with the manual transaxle and front drive axles by selecting the correct definition from four choices. Select the best answer for each term.

______1. **boot**

- A. A snap ring used to install a drive axle joint
- B. A circular clasp used around a half shaft
- C. The flange which connects the inboard joint to the transaxle
- D. A flexible cover used to protect a part

______2. **circlip**

- A. A thin metal ring which is used as a washer between parts in a C-V joint
- B. A snap ring with rounded edges which fits into a groove on a shaft and holds a part which is installed directly over it on the shaft
- C. A circular bushing used as a spacer on a shaft
- D. A rubber o-ring which fits into the transaxle housing as a part of the shift selector lever assembly

______3. **dual-range transaxle**

- A. The type of transaxle used on a four-wheel drive vehicle to change which axles drive the vehicle
- B. A mid-engine transaxle
- C. A type of transaxle which allows twice the usual number of gear ratios
- D. A type of transaxle which combines the functions of a transaxle and a drive axle

______4. **half shaft**

- A. The main shaft of a transaxle's drive axle
- B. A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle
- C. A short, splined shaft in a transaxle's drive axle which connects the outboard C-V joint to the wheel hub
- D. Any transaxle gear shaft in addition to the input shaft, output shaft, and reverse idler gear shaft

______5. **inboard** (in a vehicle)

A. In a position farthest from the midline of the vehicle
B. In a position closest to the midline of the vehicle
C. In a position inside the vehicle's frame
D. In a position outside the vehicle's frame

______6. **intermediate shaft**

A. A shaft which connects the transmission and differential sections of the transaxle
B. A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle
C. A short, splined shaft in a transaxle's drive axle which connects the outboard C-V joint to the wheel hub
D. Any transaxle gear shaft in addition to the input shaft, output shaft, and reverse idler gear shaft

______7. **link shaft**

A. An additional drive axle shaft used between two half shafts of the same length
B. A shaft which connects the transmission and differential sections of the transaxle
C. A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle
D. A short, splined shaft in a transaxle's drive axle which connects the outboard C-V joint to the wheel hub

______8. **outboard** (in a vehicle)

A. In a position farthest from the midline of the vehicle
B. In a position nearest the midline of the vehicle
C. In a position inside the vehicle's frame
D. In a position outside the vehicle's frame

______9. **output shaft drive gear**

A. The gear on a transaxle output shaft which meshes with the ring gear in the transaxle differential section
B. The transaxle output shaft speed gear through which power is flowing at any one time
C. The speed gear on the transaxle input shaft which is driving the output shaft
D. What the speedometer drive gear is called when it is located on the output shaft

_____10. **spindle shaft**

A. The main shaft of a transaxle's drive axle
B. A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle
C. A short, splined shaft in a transaxle's drive axle which connects the outboard C-V joint to the wheel hub
D. Any transaxle gear shaft in addition to the input shaft, output shaft, and reverse idler gear shaft

_____11. **stub shaft**

A. An additional drive axle shaft used between two half shafts of the same length
B. A short, splined shaft in a transaxle's drive axle which connects the inboard C-V joint to the transaxle
C. A short, splined shaft in a transaxle's drive axle which connects the outboard C-V joint to the wheel hub
D. Any transaxle gear shaft in addition to the input shaft, output shaft, and reverse idler gear shaft

_____12. **torque steer**

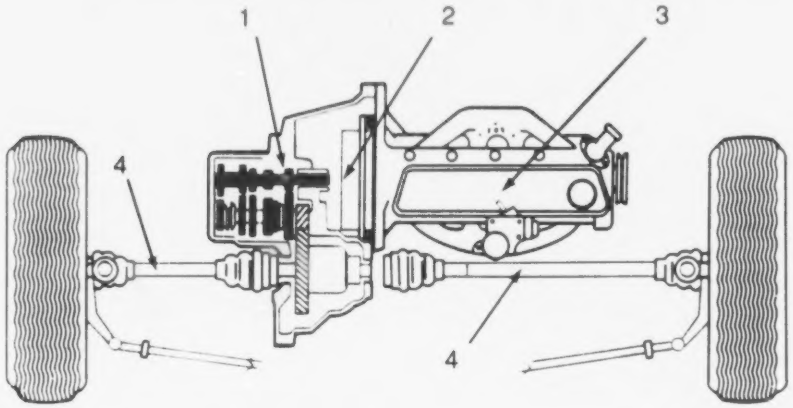
A. The tendency of an engine to twist slightly in the direction opposite to the crankshaft rotation when it speeds up
B. The tendency of an engine to twist slightly in the direction of the crankshaft rotation when it speeds up
C. A condition in which a front-wheel drive vehicle with half shafts of unequal length pulls to the side of the longer shaft during acceleration and the side of the shorter shaft during deceleration
D. A condition in which a front-wheel drive vehicle with half shafts of unequal length pulls to the side of the shorter shaft during acceleration and the side of the longer shaft during deceleration

_____13. **torquing-over**

A. The tendency of an engine to twist slightly in the direction opposite to the crankshaft rotation when it speeds up
B. The tendency of an engine to twist slightly in the direction of the crankshaft rotation when it speeds up
C. A condition in which a front-wheel drive vehicle with half shafts of unequal length pulls to the side of the longer shaft during acceleration and the side of the shorter shaft during deceleration
D. A condition in which a front-wheel drive vehicle with half shafts of unequal length pulls to the side of the shorter shaft during acceleration and the side of the longer shaft during deceleration

OBJECTIVE 2

Label the components of a front-wheel power train on an illustration. Write the name of the component indicated in the corresponding blank.



Used with permission of Ford Motor Company.

1. ______________________________

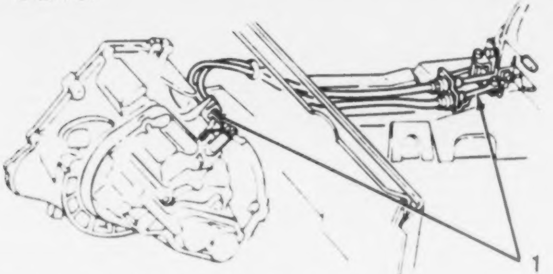
2. ______________________________

3. ______________________________

4. ______________________________

OBJECTIVE 3

Label the major sections and parts of a manual transaxle on an illustration. Write the names of the parts indicated in the blanks.



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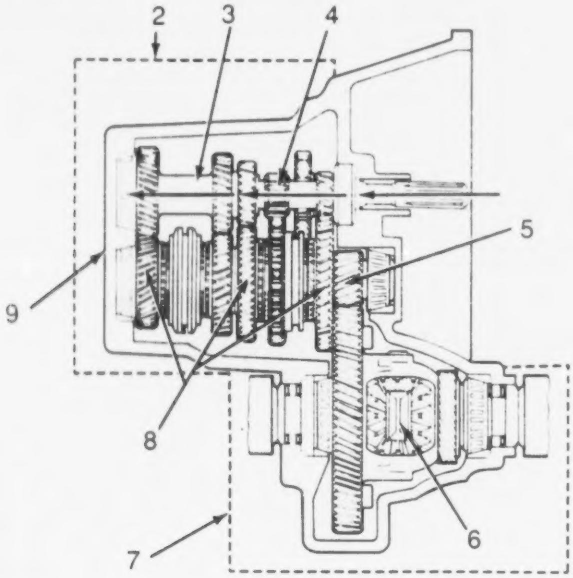
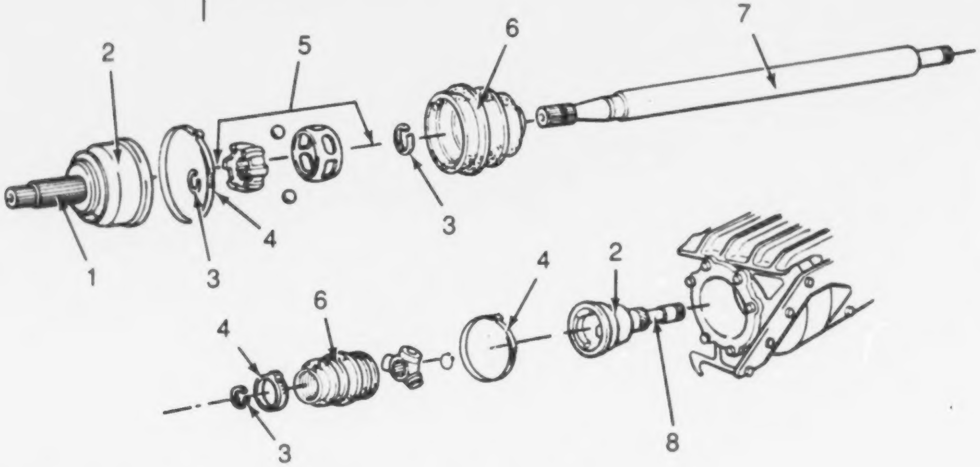


Used with permission of Ford Motor Company.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________

OBJECTIVE 4 **Match the names of the parts of a front drive axle to an illustration.** Put the letter of the correct part in the appropriate blank.



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_______1. A. Boot

_______2. B. Circlip

_______3. C. Clamp

_______4. D. C-V joint

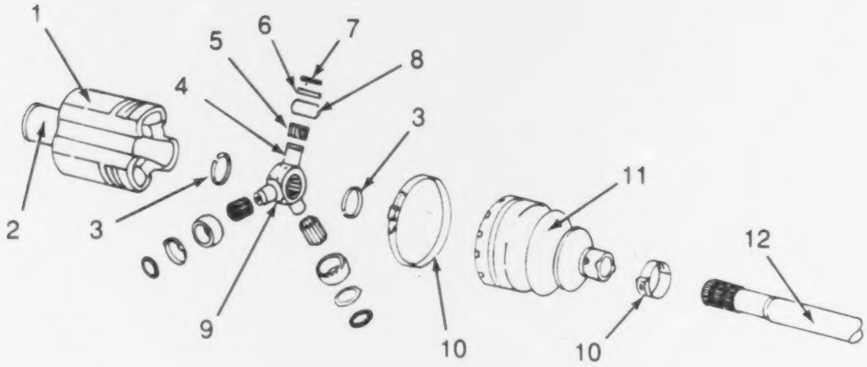
_______5. E. Half shaft

_______6. F. Outer joint housing

_______7. G. Spindle shaft

_______8. H. Stub shaft

OBJECTIVE 5 **Name four common types of drive axle joints and match the names of their parts to illustrations.** Write the name of the type of drive axle joint in the first blank and letter of the correct part in the blanks that follow.



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A. Type of drive axle joint: ______________________________

______1. A. Ball

______2. B. Boot

______3. C. Circlip

______4. D. Clamp

______5. E. Half shaft

______6. F. Needle roller retainer

______7. G. Needle rollers

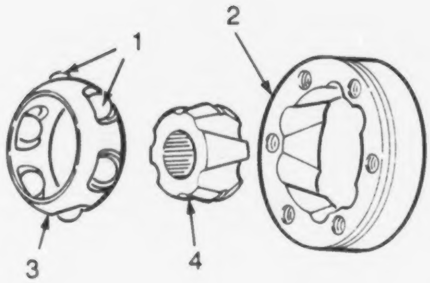
______8. H. Outer housing

______9. I. Retaining ring

_____10. J. Spider

_____11. K. Stub shaft

_____12. L. Trunnion



Used with permission of Ford Motor Company.

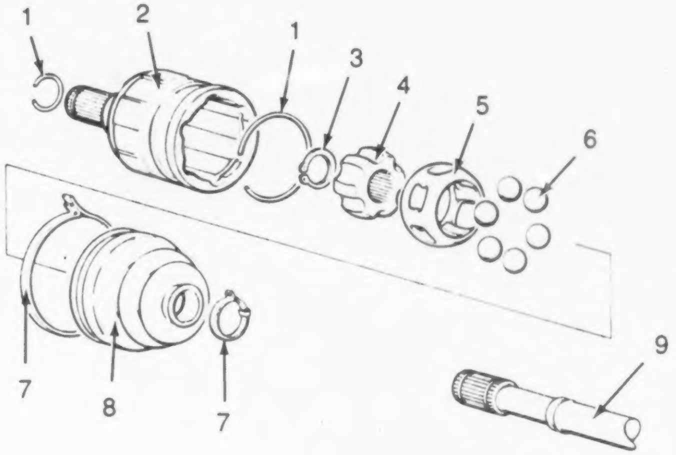
B. Type of drive axle joint: ______________________________

______1. A. Balls

______2. B. Cage

______3. C. Inner race

______4. D. Outer race



Used with permission of Chrysler Corporation.

C. Type of drive axle joint: ______________________________

______1. A. Balls

______2. B. Boot

______3. C. Cage

______4. D. Circlip

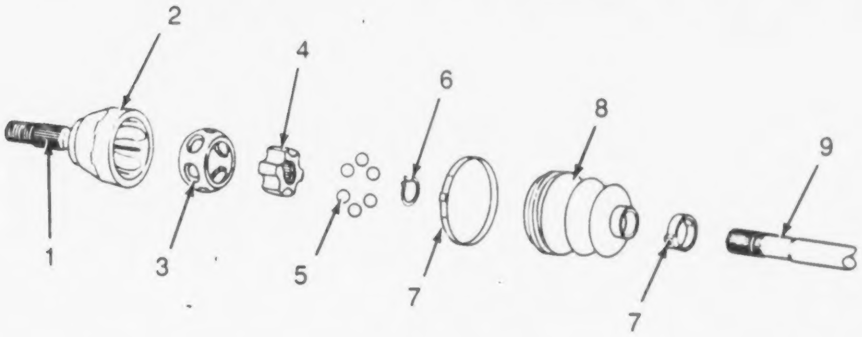
______5. E. Clamp

______6. F. Half shaft

______7. G. Inner race

______8. H. Outer race

______9. I. Snap ring



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D. Type of drive axle joint: ______________________________

______1. A. Balls

______2. B. Boot

______3. C. Cage

______4. D. Circlip

______5. E. Clamp

______6. F. Half shaft

______7. G. Inner race

______8. H. Outer race

______9. I. Spindle shaft

WRITTEN TEST ANSWERS

SERVICE MANUAL TRANSAXLES AND FRONT DRIVE AXLES *V*

OBJECTIVE 1

1. D
2. B
3. C
4. A
5. B
6. D
7. A
8. A
9. A
10. C
11. B
12. C
13. A

OBJECTIVE 2

1. Transaxle
2. Clutch
3. Engine
4. Drive axles

OBJECTIVE 3

1. Shift linkage
2. Transmission section
3. Input shaft assembly
4. Reverse idler gear assembly
5. Output shaft drive gear
6. Differential assembly
7. Differential section
8. Output shaft assembly
9. Transaxle housing

OBJECTIVE 4

1. G
2. F
3. B
4. C
5. D
6. A
7. E
8. H

OBJECTIVE 5

A. Tripod Joint

1. H
2. K
3. C
4. L
5. G
6. F
7. I
8. A
9. J
10. D
11. B
12. E

B. Cross Groove Joint

1. A
2. D
3. B
4. C

C. Double Offset Joint

1. D
2. H
3. I
4. G
5. C
6. A
7. E
8. B
9. F

D. Rzeppa Joint

1. I
2. H
3. C
4. G
5. A
6. D
7. E
8. B
9. F

OBJECTIVE SHEET

SERVICE FOUR-WHEEL DRIVE VI

INTRODUCTION

Automotive

Four-wheel drive vehicles use a special drivetrain design to deliver performance advantages under off-road conditions and in poor weather. Like front-wheel drive vehicles, four-wheel drive vehicles are becoming increasingly popular. There are a large number of models available, and they use different design solutions to problems unique to four-wheel drive. These variations in design create new challenges for the Drivetrain and Axles Specialist who services, diagnoses, and repairs these vehicles.

PREREQUISITE

Before studying this unit, the student must have successfully completed Unit 5, *Service Manual Transaxles and Front Drive Axles.*

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose, service, and repair drivetrain components of a four-wheel drive vehicle. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Choose the correct definitions for terms associated with four-wheel drive vehicles by selecting the correct definition from four choices.
2. List the advantages and disadvantages of using four-wheel drive.
3. Match the names of the components of a four-wheel drivetrain to an illustration.
4. Label the major types of transfer cases and match the names of their parts to illustrations.

5. Match the names of the parts of a planetary gear assembly to illustrations.

6. List three ways the front drive axles can be disconnected in a four-wheel drive vehicle.

7. Label the major types and parts of front drive axles used on four-wheel drive vehicles on illustrations.

8. Diagnose four-wheel drive assembly noise and performance problems. (Assignment Sheet 1)

9. Demonstrate the ability to:

   A. Inspect, adjust, and repair transfer case shifting components. (Job Sheet 1)

   B. Remove an independent four-wheel drive transfer case. (Job Sheet 2)

   C. Remove, inspect, service, and replace transfer case components. (Job Sheet 3)

   D. Remove and inspect front steering knuckles and drive axle assemblies. (Job Sheet 4)

   E. Inspect, service, and replace front wheel bearings and locking hubs. (Job Sheet 5)

   F. Service and replace front steering knuckles and drive axle assemblies. (Job Sheet 6)

   G. Replace an independent four-wheel drive transfer case and complete service. (Job Sheet 7)

SERVICE FOUR-WHEEL DRIVE

PREPARATION

Review unit and plan presentation

- Study the specific objectives to determine the order in which you will present the objectives. Decide whether or not you wish to add additional objectives.
- Review teaching suggestions given in the Delivery section and plan classroom activities.
- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.
- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the qustions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

Obtain supplemental materials

- Order films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrates job sheet skills. Videotape your own procedures if unable to obtain suitable media.
- Copies of current articles on subjects covered in this unit may be obtained by writing to the *Automotive Information Council's* Reference Center. They will also conduct a computer search for such articles. See the note in the section on Media for more information about this free service.
- Obtain competency profiles for this unit.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364, 1-800-522-5810, ext. 589 in-state; 1-800-654-4502 out-of-state.

- Note equipment and material needs for completing job sheets.

Prepare classroom and shop

- Display safety signs, posters, and charts that show four-wheel drive drivetrains, components, and service, etc.
- Have magazine articles, specification guides, service manuals, mock-ups, and other references for four-wheel drive vehicles, transfer cases, and four-wheel drive components available for student use.
- Check tools and equipment against job sheet requirements.

Administer Pretest

- Administer the pretest.
- Use the pretest results to assess student competencies, considering the results as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the introduction to the unit the Objective Sheet.
- Discuss the unit objective and then the specific objectives.
- Raise a four-wheel drive vehicle and show the students the components covered by this unit.

Objective 1 Choose the correct definitions for terms associated with four wheel drive vehicles by selecting the correct definition from four choices.

- Show examples or demonstrate terms where applicable.

Objective 2 List the advantages and disadvantages of using four-wheel drive.

- Explain the advantages and disadvantages of using four wheel drive from both the drivetrain technician's and the driver's point of view.
- Invite an owner and user of four-wheel drive to the class to answer students' questions about the advantages and disadvantages experienced with this type of vehicle.

- Show the method of shifting transfer case gears in as many different kinds of four-wheel drive vehicles as possible.

Objective 3 Match the names of the components of a four-wheel drivetrain to an illustration.

- Show the students the components of a four-wheel drive vehicle on an actual vehicle.

- Explain the differences (if any) between drivetrain components found on four-wheel drive vehicles and the same components on two-wheel drive vehicles.

- Discuss the boxed material on "All-Wheel Drive," pointing out the differences between a four-wheel drive and an all-wheel drive vehicle.

- Show the students an example of an all-wheel drive vehicle, and discuss the advantages and disadvantages of this type of vehicle.

- Have the students research at least five different models of four-wheel drive vehicle and include in their research: the type of transfer case used; whether or not the transfer case is independent or part of the transmission; if it has a full-time transfer case; the type of front drive axle; the type of shift linkage; how the range and mode shifts are made inside the vehicle; any other features significant to the Drivetrain and Axles Specialist.

Objective 4 Label the major types of transfer cases and match the names of their parts to illustrations.

- Display an actual example of each type of transfer case and demonstrate how it works.

- Show an example of a transfer case which is part of a transmission and one which is part of a transaxle.

- Discuss the boxed material, "Adjusting Power Flow to the Front and Rear Axles."

- Discuss the material in the box, "Transfer Case Gear Shift," explaining the advantage of providing an additional gear multiplication for four-wheel drive vehicles.

- Discuss the boxed material, "Advantages of a Chain-Driven Transfer Case."

- Show an example of a transfer case using a limited-slip differential and have a student review the class on how a limited-slip differential operates.

- Show the students an example of a lock-out mechanism and demonstrate how it is activated from inside the vehicle.

- Display at least one actual example of a viscous coupling and explain how it works and how it is serviced.

- Tell the students other locations where viscous couplings are used in vehicles.

- Go over the boxed material, "Operation of a Gear-Driven Transfer Case."

Objective 5 Match the names of the parts of a planetary gear assembly to illustrations.

- Let the students handle an example of a simple planetary gear set while you point out its parts.

- Have the students quiz each other, naming the parts.

- Discuss the boxed material, "How a Planetary Gear Changes Torque Speed and Power," and "Planetary Gear Assembly in a Transfer Case."

- Show them examples of several planetary gear sets which are actually used in transfer cases and demonstrate how they work inside the case.

- Discuss the function of the planetary gear set in the transfer case.

Objective 6 List three ways the front drive axles can be disconnected in a four-wheel drive vehicle.

- Discuss the boxed material, "Why Do the Front Wheels Need to Be Disconnected?"

- Show examples of locking hubs as they are found on a vehicle. Let the students move the control knobs to change the settings. As they do, explain what is happening in the mechanism and how the vehicle will operate differently with the hubs locked, unlocked, and/or on automatic setting.

- Display examples of several different makes of locking hubs in the classroom and explain how their inner mechanisms work.

- Discuss the disadvantages of automatic locking hubs and why the driver may sometimes want to lock these hubs manually.
- Show examples of both an electric and a vacuum-operated front axle disconnect mechanism and explain how they work

Objective 7 Label the major types and parts of front drive axle used on four-wheel drive vehicles on illustrations.

- Explain that the parts shown on the illustrations include part of other assemblies which interact critically with the front drive axle.
- Show the students examples of both types of front drive axle assemblies both on and off a vehicle.
- Allow the students to handle the axle parts in the classroom as you explain the function of every part, including those parts which join the axle to other systems and assemblies, such as steering, suspension, hubs, brakes, etc.
- Discuss the advantages and disadvantages of the two types of axles.
- Have the students research a list of four-wheel drive vehicles which use each type of front axle assembly.

APPLICATION

Objective 8 Diagnose four-wheel drive assembly noise and performance problems. (Assignment Sheet 1)

- Review Supplement 1, "Four-Wheel Drive Troubleshooting Guide," discussing each step.
- Stress the importance of using your knowledge of the entire drivetrain to pinpoint problems with four-wheel drive vehicles.
- Demonstrate on an actual vehicle how to troubleshoot the electrical and vacuum systems on a four-wheel drive vehicle.
- Show the students how to test the viscous coupling following the steps in Supplement 1.
- Review Supplement 2, "Transfer Case Noise, Leak, and Performance Diagnosis Chart."
- Have the students complete Assignment Sheet 1.

Objective 9A Inspect, adjust, and repair transfer case shifting components. (Job Sheet 1)

- Show the students examples of different types of shift linkages (both manual and electric) for four-wheel drive vehicles and explain how they work.
- Discuss the difference between a *mode fork* and a *range fork* in a shifting mechanism.
- Use the vehicle's service manuals to demonstrate how to inspect, adjust, and repair these shifting components.
- Show the students examples of shift linkages for a front axle disconnect mechanism and a rear wheel anti-locking brakes disconnect mechanism.
- Discuss the operation of anti-locking brakes and explain why their action is undesirable under four-wheel drive conditions.
- Have the students complete Job Sheet 1.

Objective 9B Remove an independent four-wheel drive transfer case. (Job Sheet 2)

- Explain the function of a *skid plate*, and tell or show the students common places where they might be found.
- Point out the skid plate in the photograph in the Objective Sheet.
- Demonstrate how to safely disconnect electrical wires to the transfer case.
- Discuss the functions of vent hoses in four-wheel drive vehicles.
- Show examples of vent hoses and demonstrate how to inspect and service them.
- Demonstrate the procedures in Job Sheet 2, giving special emphasis to procedures involving systems and components with which the student may not be familiar, such as the exhaust system components.
- Have the students complete Job Sheet 2.

Objective 9C Remove, inspect, service, and replace transfer case components. (Job Sheet 3)

- Show the filmstrips, *Four-Wheel Drive: Overhauling the New Process 203 Transfer Case.*
- Stress the fact that transfer cases are designed differently and that the vehicle service manual is the only reliable guide for completing this job sheet.
- Review the Guidelines given for the job sheet.
- Demonstrate how to remove, inspect, service, and replace the transfer case components in one of the four-wheel drive vehicles in your shop.
- Have the students complete Job Sheet 3.

Objective 9D Remove and inspect front steering knuckles and drive axle assemblies. (Job Sheet 4)

- Show the students different types of suspension and steering knuckle arrangements.
- Demonstrate how to use any tools unfamiliar to the students, such as axle nut wrenches, hub pullers, and tie rod separators or pullers.
- Demonstrate the procedures in Job Sheet 4, giving special emphasis to procedures involving systems and components with which the student may not be familiar, such as the steering, suspension, and brake system components.
- Have the students complete Job Sheet 4.

Objective 9E Inspect, service, and replace front wheel bearings and locking hubs. (Job Sheet 5)

- Show the four filmstrips, *Four-Wheel Drive: Front Wheel Hub Service.*
- Review the procedures in Supplement 5, Unit 2, for inspecting, cleaning, and lubricating anti-friction bearings.
- Demonstrate the procedures in Job Sheet 5 on several different types of locking hubs.
- Have the students complete Job Sheet 5.

Objective 9F Service and replace front steering knuckles and drive axle assemblies. (Job Sheet 6)

- Display several different types of steering knuckles and let the students handle them.
- Point out the different parts of a steering knuckle and explain how the knuckle operates.
- Demonstrate the procedures in Job Sheet 6.
- Have the students complete Job Sheet 6.

Objective 9G Replace an independent four-wheel drive transfer case and complete service. (Job Sheet 7)

- Discuss transfer case lubrication and show the students examples of lubricants used in transfer cases.
- Demonstrate the procedures in Job Sheet 7.
- Have the students complete Job Sheet 7.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate class members on assignment sheet activities if not previously done. Provide them with copies of Supplement 1, "Four-Wheel Drive Troubleshooting Guide," and Supplement 2, "Transfer Case Noise, Leak, and Performance Chart."
- Give the practical tests. Evaluate the tests on forms provided.
- Reteach and retest as required
- Complete the appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods.
- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- Abbott, Sheldon L. *Automotive Power Trains*, 2nd ed. Encino, California: Glencoe Publishing Co., 1988.

- *Bearings and Seals*, 3rd ed. Moline, Illinois: Deere & Co., 1980.
- Brooke, Lindsay, "Four Wheel Drive-In, All the Ways the Wheels Are Driven in 1988." *Automotive Industries Magazine*, March 1988, pp. 50-52.
- *Chilton's Auto Repair Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- *Chilton's Import Car Manual 1983-1990*. Radnor, Pennsylvania: Chilton Book Co., 1989.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill, 1985.
- Crouse, William H., and Donald L. Anglin. *Manual Transmissions and Power Trains*, 6th ed. New York: Gregg Division, McGraw-Hill, 1983.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- *Engine, Clutch, & Drive Axle Service & Repair. Imported Cars & Trucks. 1988 Supplement*. San Diego, California: Mitchell Manuals, Inc., 1984.
- Erjavec, Jack. *Manual Transmissions and Transaxles*. New York City, New York: Harcourt Brace Jovanovich, Technology Publications, 1990.
- Hughes, James G. *Guide to Automobile Certification Examination*, revised ed. Reston, Virginia: Reston Publishing Co., Inc., a Prentice-Hall company, 1983.
- *Introduction to Automotive Service*. Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1989.
- Kovacik, Robert T., and Clifford Creager. *Manual Transmissions and Drivetrains*. Cincinnati, Ohio: South-Western Publishing Co., 1984.
- Mitchell Information Services, Inc. *Mitchell Automechanics*. Englewood Cliffs, New Jersey: Prentice-Hall, 1986.

- *1988 K-Series Truck.* Detroit, Michigan: General Motors Corp., 1987.
- *1988 Light Duty Truck—Unit Repair Manual.* Detroit, Michigan: General Motors Corp., 1987.
- *1989 Service Manual - Civic Wagon*, 1st ed. Japan: Honda Motor Co., Ltd. 1988.
- *Official ASE Preparation Guide to ASE Automobile Tests, The.* Reston, Virginia: National Institute for Automotive Service Excellence, 1989.
- *Pontiac 6000 STE All Wheel Drive.* Detroit, Michigan: General Motors Corp., 1988.
- *Service Manual—Jeepster Series Vehicles.* Toledo, Ohio: Kaiser Jeep Corp., 1967.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1982.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.
- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1983.
- *208 Transfer Case and Automatic Locking Hubs.* Detroit, Michigan: General Motors Corp., 1980.
- Webster, Jay. *Auto Mechanics*, 2nd ed. Encino, California: Glencoe Publishing Co., Inc., 1986.
- Webster, Jay. *Automotive Power Train Systems.* Homewood, Illinois: American Technical Publishers, Inc., 1982.
- White, John H. *Manual Transmissions and Drivetrains.* Albany, New York: Delmar Publishers Inc., 1987.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Automotive Information Council—Reference Center*. 13505 Dulles Technology Drive, Herndon, Virginia 22071-3415, phone (703) 904-0700. The AIC Reference Center has a reference base of over 10,000 volumes, maintaining subscriptions to over 100 trade and consumer publications relating to the automotive industry. Their computer indexing system can provide educators with up-to-date print-outs of books, articles from periodicals, statistical abstracts, press releases, catalogues, and other reference materials on 90 automotive subject classifications. AIC's services are free of charge. Copies of current articles from periodicals are also available free if requested in nominal quantities.

- *Four-Wheel Drive: Front Wheel Hub Service*. 4 filmstrips. Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050, phone 1-800-431-3565. Warn Locking Hub: Disassembly; Warn Locking Hub: Assembly; Spicer Internal-Type Hub: Disassembly; Spicer Internal-Type Hub: Assembly.

- *Four-Wheel Drive: Overhauling the New Process 203 Transfer Case*. 4 filmstrips. Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050, phone 1-800-431-3565. Disassembling the Case; Input Shaft Components: Disassembly, Inspection and Reassembly; The Range Selector Housing: Assembly; Chain Housing Parts Installation and Completing the Assembly.

SERVICE FOUR-WHEEL DRIVE

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions:

Objective	Question
1	1,2
2	3
3	4
4	5
5	6
6	7
7	8
8	9, 10
9A	11
9B	12
9C	13
9D	14
9E	15
9F	16
9G	17

ANSWER KEY

1. D
2. A
3. B
4. A
5. C
6. B
7. A
8. C
9. B
10. C
11. B
12. C
13. C
14. D
15. A
16. B
17. B

PRETEST

SERVICE FOUR-WHEEL DRIVE

VI

NAME ______________________ SCORE ______

DIRECTIONS

Read the following questions and problems, then put the letter of the item that best answers the question or solves the problem in the blank.

______1. The difference between a full-time and a part-time transfer case is:

A. A full-time transfer case transfers torque all the time and a part-time case only transfers torque part of the time
B. A part-time transfer case can be disconnected from the vehicle's drivetrain and a full-time transfer case can't
C. A part-time transfer case only transfers torque to the rear drive axles and a full-time transfer case transfers torque to both the front and the rear drive axles
D. A full-time transfer case transfers torque to the front and rear drive axles all the time and a part-time transfer case transfers torque to *either* the rear drive axles *or* to both the front and the rear drive axles

______2. A front axle disconnect mechanism is located between one of the front drive axles and the:

A. Front differential
B. Transfer case
C. Front driveline
D. Transmission

______3. Which of the following is **not** an advantage of four-wheel drive?

A. Better traction in off-road conditions
B. More engine power
C. Can be towed safely without damaging the transmission
D. Increased power availability

______4. How does an all-wheel drive vehicle differ from an ordinary four-wheel drive vehicle?

A. It has a transaxle rather than a transmission
B. It has both a front and a rear drive axle
C. It uses a viscous coupling
D. It is found only in trucks

______5. Which of the following is the most common type of transfer case?

A. All-wheel drive transfer case
B. Full-time transfer case
C. Part-time chain-driven transfer case
D. Part-time gear-driven transfer case

______6. The transfer case component that increases the power of the torque coming from the transmission is the:

A. Viscous coupling
B. Planetary gear assembly
C. Chain drive
D. Clutch gear

______7. Technician A says that locking hubs disconnect both drive wheels from the drive axle. Technician B says that a front axle disconnect mechanism does the same thing. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

______8. Which of the following does **not** usually operate inside a housing?

A. Solid front axle assembly
B. Front differential
C. Independent front axle assembly
D. Transaxle

______9. A technician who is diagnosing problems on a four-wheel drive vehicle has jacked up one front wheel and is turning the wheel with a torque wrench attached to a lug nut on the wheel. What is he doing?

A. Testing the locking hub
B. Testing the viscous coupling
C. Measuring transfer case torque
D. Removing the wheel

______10. Technician A says that a transfer case jumping out of gear could be caused by an improperly adjusted shift linkage. Technician B says that this problem could be caused by loose transfer case mounts. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

______11. In a four-wheel drive vehicle, the mode fork inside the transfer case shifts the vehicle back and forth:

A. From HI to LO
B. From 4-wheel drive to 2-wheel drive
C. From DRIVE to NEUTRAL
D. Into OVERDRIVE

______12. Technician A says that transfer cases are separate independent units located behind the transmission. Technician B says that transfer cases are sometimes built into the transmission or transaxle. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

______13. Which of the following components is found **only** in a chain-driven transfer case?

A. Front output shaft
B. Rear output shaft
C. Sprocket assembly
D. Shift forks

_____14. The component which joins and coordinates the front drive axle, steering, and suspension systems is the:

A. Tie rod
B. C-V joint
C. Control arms
D. Steering knuckle

_____15. When disassembling a manual locking hub, the hub control knob should be set at:

A. UNLOCK
B. LOCK
C. AUTOMATIC
D. It makes no difference

_____16. Technician A says that the removal procedures for a solid front axle and a solid rear axle are the same. Technician B says that the removal procedures are different. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____17. The lubricant most commonly used in the transfer cases of late model domestic vehicles is:

A. Standard transmission fluid
B. Automatic transmission fluid
C. Gear oil
D. Multi-purpose lubricant

INFORMATION SHEET

SERVICE FOUR-WHEEL DRIVE

VI

OBJECTIVE 1

Choose the correct definitions for terms associated with four-wheel drive vehicles by selecting the correct definition from four choices.

all-wheel drive vehicle — A type of full-time four-wheel drive vehicle which has a transfer case built into its transaxle

automatic locking hub — A locking hub which will connect or disconnect the drive wheel and the drive axle automatically, without its hub control knob being set by hand

four-wheel drive vehicle — A type of vehicle designed to allow all four wheels to drive the vehicle at the same time

front axle disconnect mechanism — A special assembly built into the front drive axle which allows one of the front drive axles to be automatically connected and disconnected from the front differential

full-time transfer case — A type of transfer case which transfers torque from the transmission to both the front and the rear drive axles at all times

independent front axle assembly — A type of front drive axle which typically has constant velocity joints at both ends of each half shaft and is not contained in an axle housing

lock-out mechanism — A special assembly used with a transfer case differential which can be set manually to lock up the differential action and force an equal supply of power to both axles

locking hub — A type of hub used on front drive wheels which allows the wheel to be connected or disconnected to the drive axle

manual locking hub — A locking hub which will connect or disconnect the drive wheel to the drive axle only if its hub control knob is set by hand

part-time transfer case — A type of transfer case which can transfer torque from the transmission to *either* the rear drive axles *or* to both the front and rear drive axles

solid front axle assembly — A type of front drive axle which has a universal joint only at the outboard end of each axle and is contained in an axle housing

steering knuckle — A steering system component which connects the steering linkage to the front drive axles and sometimes the front suspension

transfer case — A drivetrain component in a four-wheel drive vehicle which accepts torque from the transmission and transmits it to the front and rear drive axles

viscous coupling — A unit that transfers torque between two drivetrain components using a fluid (such as silicone) which allows for a degree of slippage between the components

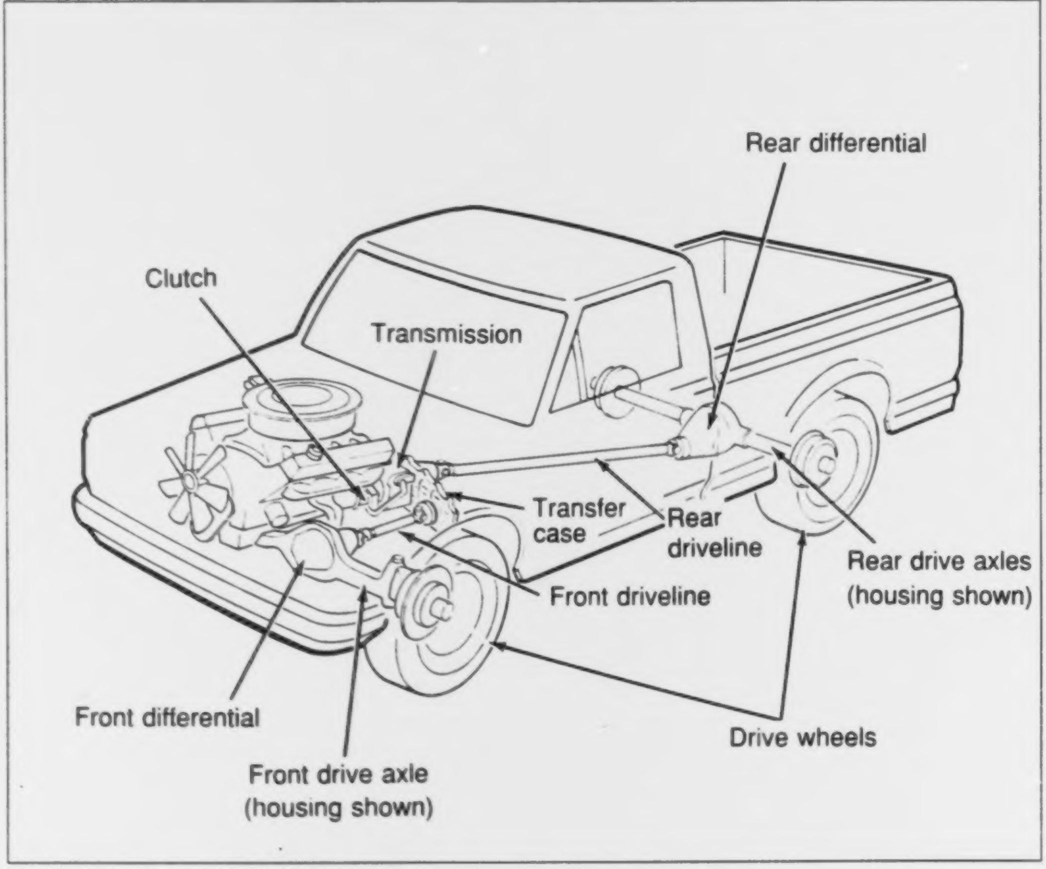
OBJECTIVE 2 | **List the advantages and disadvantages of using four-wheel drive.**

ADVANTAGES	*Reason*
Better traction for driving in off-road situations, in sand, mud, deep snow, and on ice	Four drive wheels available, greater vehicle weight
Increased power availability	Additional gear multiplication available in most transfer cases
Can be towed safely without damaging the transmission	Front and rear axles can be disconnected from the transmission at the transfer case

DISADVANTAGES	*Reason*
Greater vehicle weight	Additional drivetrain components
Less horsepower to the wheels	The transfer case divides engine power to turn an additional axle assembly
Increased drivetrain friction	Longer, more complex drivetrain containing additional drivetrain components
Decreased fuel economy	Greater vehicle weight, increased drivetrain friction
Greater tire wear	All wheels are driving wheels; increased traction = increased wear
Higher maintenance costs	Additional drivetrain components, more complex controls, greater tire wear, decreased fuel economy

OBJECTIVE 3 **Match the names of the components of a four-wheel drivetrain to an illustration.**

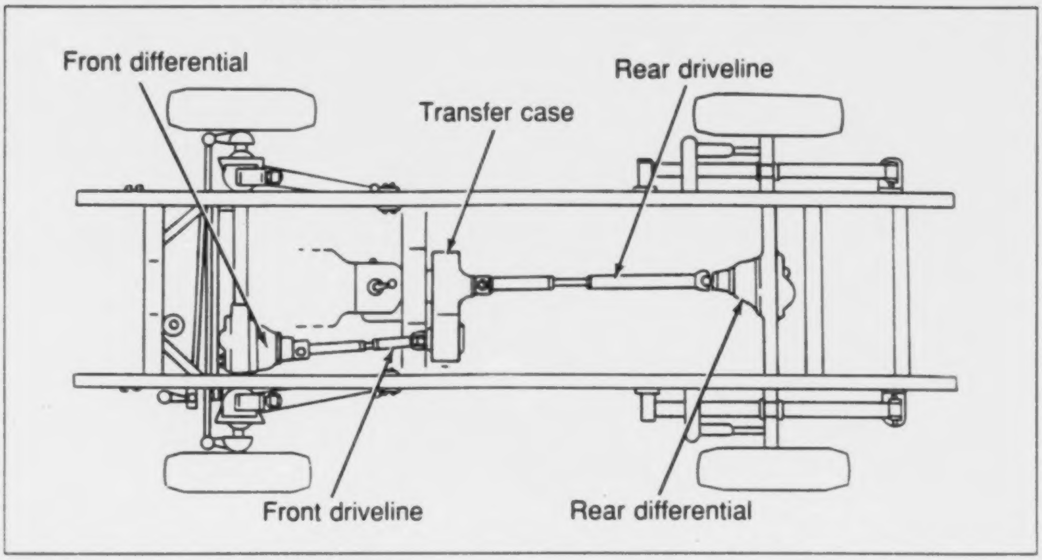
FIGURE 1


Rear differential
Clutch
Transmission
Transfer case
Rear driveline
Rear drive axles (housing shown)
Front driveline
Front differential
Drive wheels
Front drive axle (housing shown)

Used with permission of Ford Motor Company.

NOTE: The heart of a four-wheel drivetrain is the ***transfer case***, a drivetrain component which accepts torque from the transmission and transmits it to the front and rear drive axles. Most transfer cases are a separate unit located to the rear of the transmission, however some transfer cases are built into the transmission. In addition to a front and a rear driveline, a few four-wheel drive vehicles (mostly medium-duty trucks) have a short ***third driveline*** between the transmission and the transfer case.

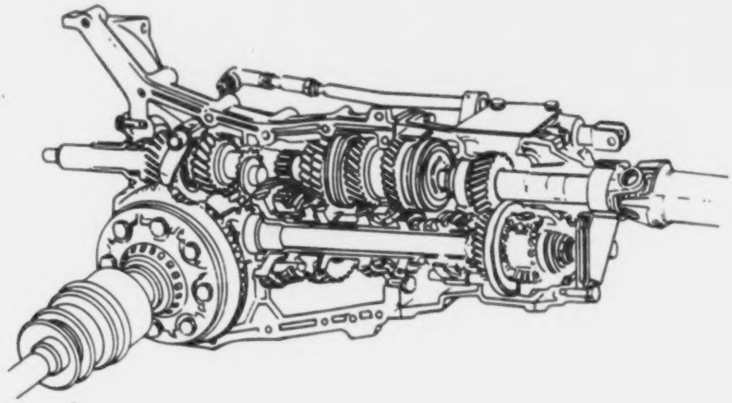
FIGURE 2


Front differential
Rear driveline
Transfer case
Front driveline
Rear differential

Used with permission of Ford Motor Company.

ALL-WHEEL DRIVE

An ***all-wheel drive*** vehicle is a type of full-time four-wheel drive vehicle which has a transfer case built into a transaxle. Found almost exclusively on cars, the special transaxle designs for all-wheel drive include a rear output shaft as well as front axle shafts.



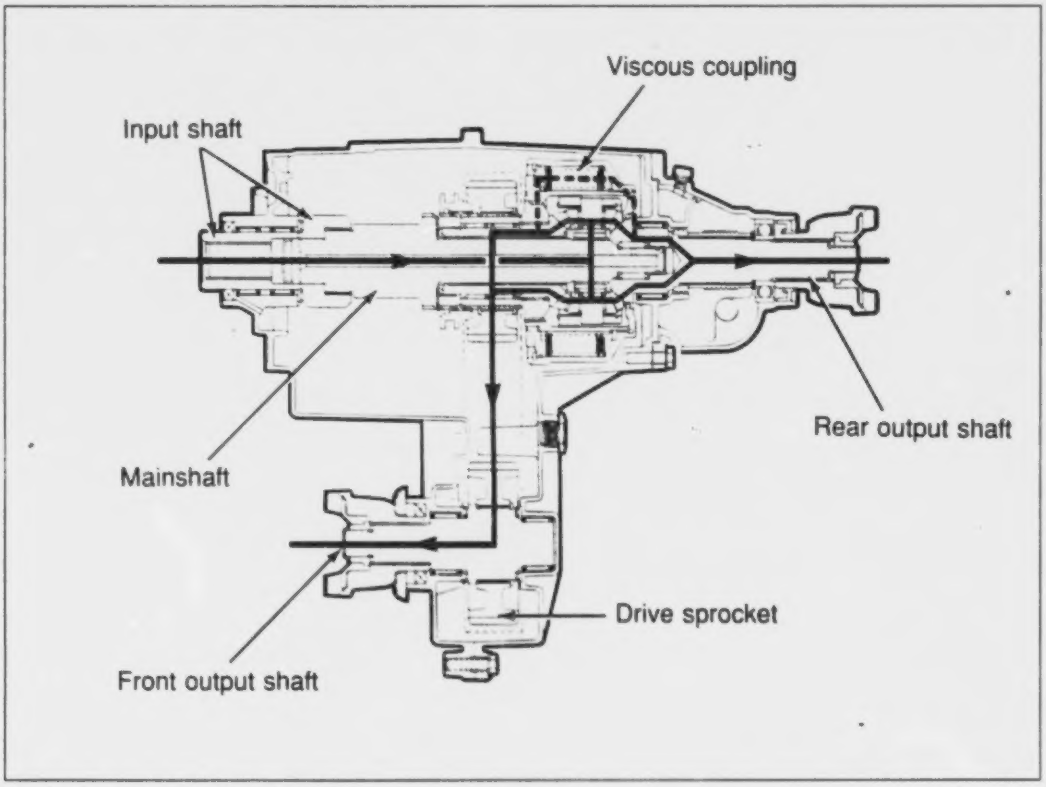
Used with permission of Subaru.

NOTE: Although an all-wheel drive vehicle is a *type* of four-wheel drive and a four-wheel drive vehicle is driven by *all* wheels, be sure ***not*** to use the terms interchangeably. If you are referring to an *all-wheel drive* vehicle, use the correct term. If the vehicle has a four-wheel drive, but is not an all-wheel drive vehicle, call it a *four-wheel drive* vehicle.

OBJECTIVE 4 **Label the major types of transfer cases and match the names of their parts to illustrations.**

FULL-TIME TRANSFER CASE

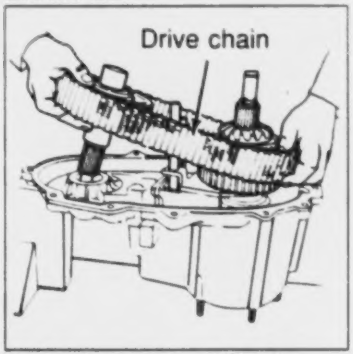
FIGURE 3


Viscous coupling
Input shaft
Rear output shaft
Mainshaft
Drive sprocket
Front output shaft

Used with permission of Chrysler Corporation.

NOTE: A **full-time transfer case** transfers torque from the transmission to both the front and the rear drive axles *at all times*. All full-time transfer cases are chain-driven, with torque carried from the mainshaft to the front output shaft by a chain and sprocket assembly. (See example at right.) A full-time transfer case has a third differential or a viscous coupling built into the case which adjusts the flow of power to the differentials in the front and the rear drive axles. A viscous coupling is used in the transfer case shown. Full-time transfer cases are more often found on cars than on trucks. The bold line on the illustration above shows the flow of power through the transfer case.

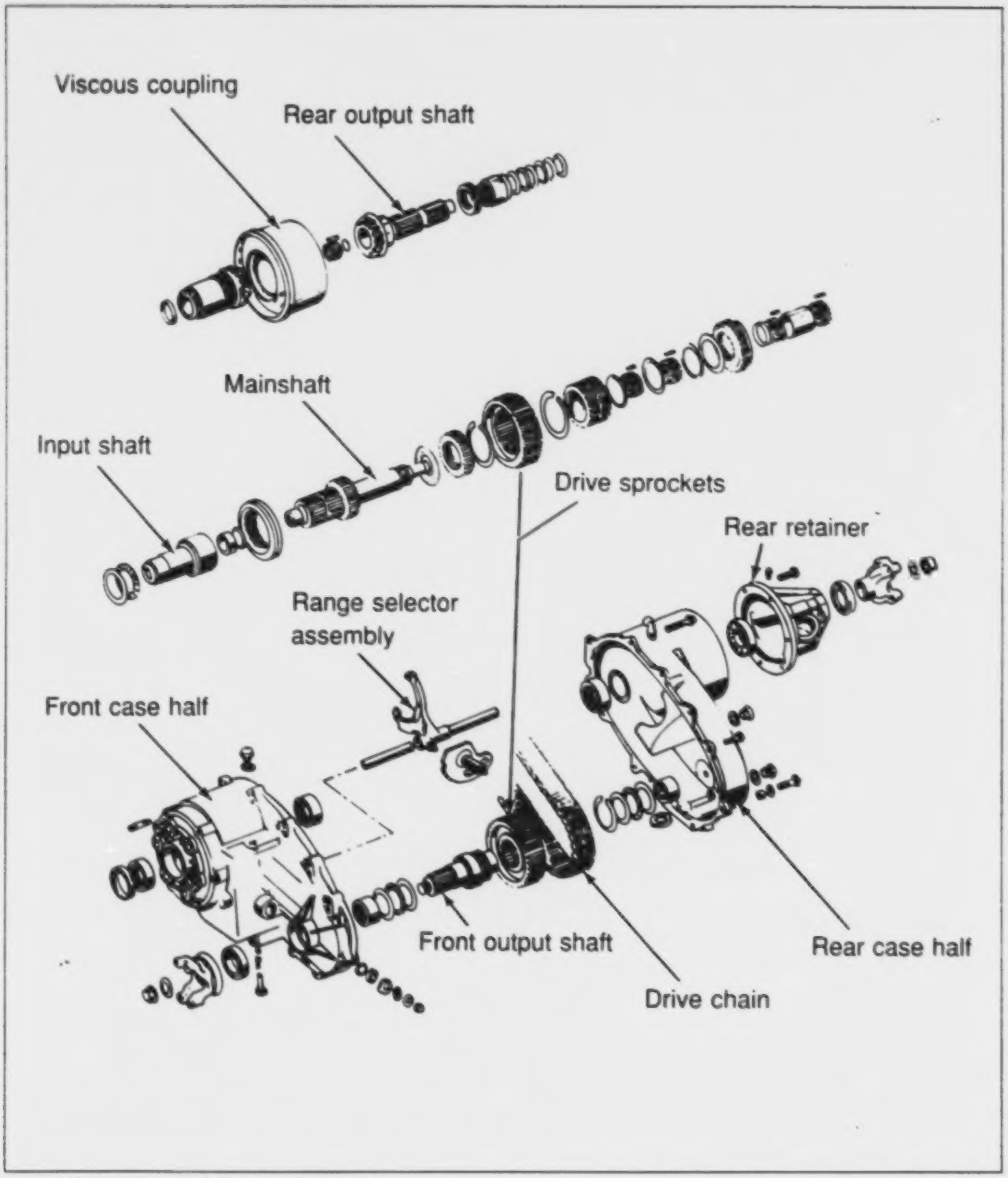
EXAMPLE:


Drive chain

Used with permission of Chrysler Corporation.

EXAMPLE:

FIGURE 4


Viscous coupling
Rear output shaft
Mainshaft
Input shaft
Drive sprockets
Rear retainer
Range selector assembly
Front case half
Front output shaft
Rear case half
Drive chain

Used with permission of Chrysler Corporation.

NOTE: An I.D. tag on the transfer case will tell you the manufacturer and model number of the case.

ADJUSTING POWER FLOW TO THE FRONT AND REAR AXLES

A full-time four-wheel drive vehicle handles well except when turning a corner on dry pavement. During such a turn, the front wheels must travel farther than its rear wheels because they are used to steer. But since the front and rear wheels must turn at the same speed, the vehicle responds as though the front brakes were on. This problem is avoided on a part-time four-wheel drive vehicle because it can be shifted to two-wheel drive on dry pavement.

The differential in a rear axle divides the torque coming from the driveline and adjusts the amount of power going to each wheel so that the outer wheel receives more torque when the vehicle is turning a corner. In much the same way, a differential built into a full-time transfer case divides the torque so the front and rear axles can rotate at different speeds.

However, when the vehicle is operating off-road or in slippery conditions, it is not always desirable to have the torque divided in this manner. If the wheels on one axle lose traction and begin to spin, the differential will give that axle the most torque and the other axle will not have enough power to drive the vehicle out of the situation. Three methods are used to solve this problem:

- A ***limited-slip differential*** is used in the transfer case.
- A manually-operated ***lock-out mechanism*** can be used which will lock up the differential action and force an equal supply of power to both axles.
- A ***viscous coupling*** is used instead of a differential. A viscous coupling is a unit that transfers torque between two drivetrain components using a fluid (such as silicone) which allows for a degree of slippage between the components. In a viscous coupling, a number of thin discs are stacked close together in a cylinder-shaped housing filled with a heavy silicone oil. Half of the discs are fixed to the housing and the front driveline and the other half are sandwiched between these discs and splined to the rear driveline. When the two drivelines are rotating at the same speed, the coupling operates freely. However if one driveline begins to rotate faster or slower than the other, the friction created between the discs instantly causes the silicone oil to heat up and bind the discs together in proportion to the difference in the speed of rotation.

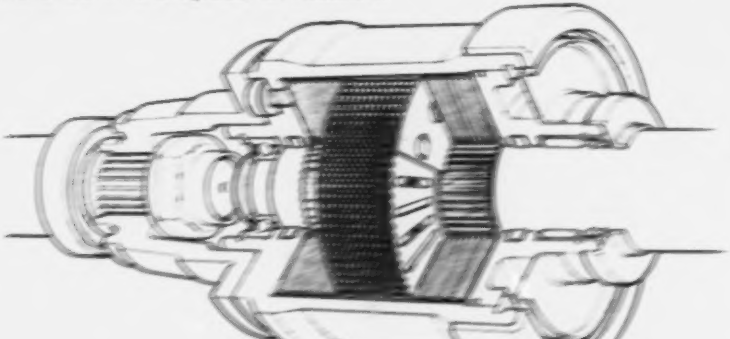


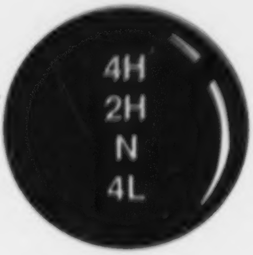
Illustration used with permission of American Honda Motor Co., Inc.

ADVANTAGES OF A CHAIN-DRIVEN TRANSFER CASE

- Lighter weight
- Quieter
- Stronger
- The driver does not need to come to a complete stop before shifting between 2 and 4-wheel drive.

TRANSFER CASE GEAR SHIFT

In addition to the regular gear settings available from the transmission, most vehicles with four-wheel drive have an additional gear range which provides a power increase. The following are the transfer case gear changes commonly available.



4 H — Four wheel drive, high. All four wheels drive the vehicle. There is a direct one-to-one ratio from the transmission through the transfer case.

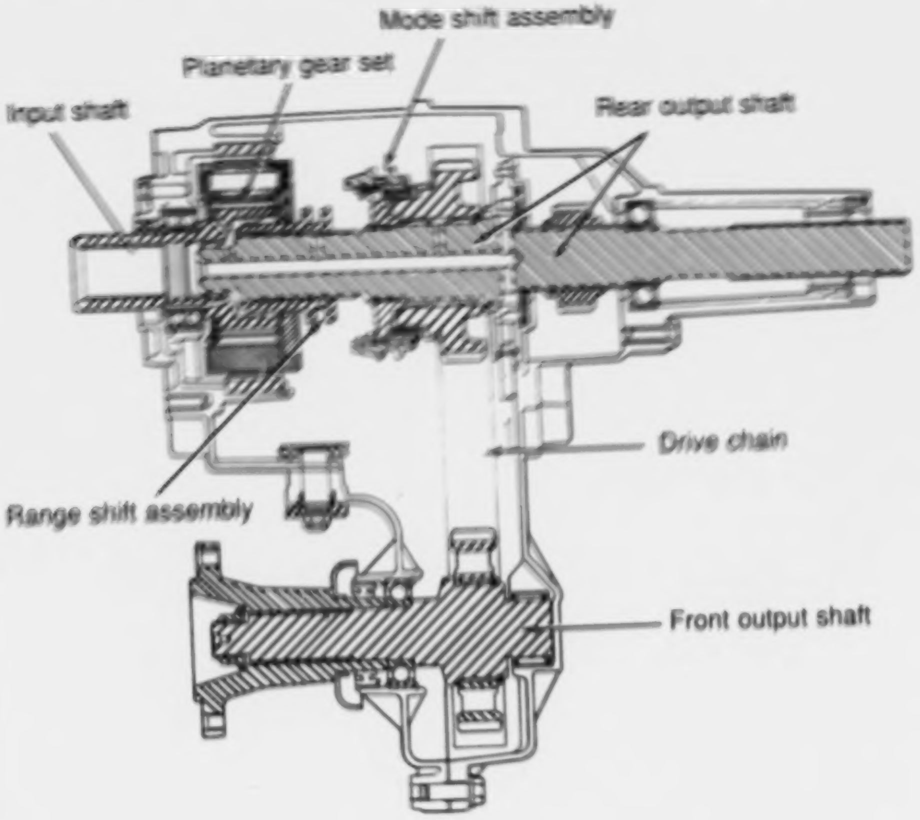
2 H — Two wheel drive, high. Only the rear two wheels drive the vehicle. There is a direct one-to-one ratio through the transfer case.

N — Neutral. Even though the engine is running and the transmission in gear, the transfer case is not transferring torque to the drive axles.

4 L — Four wheel drive, low. All four wheels drive the vehicle. There is a 2 or 2.5 :1 gear change made in the transfer case.

PART-TIME CHAIN-DRIVEN TRANSFER CASE

FIGURE 5


Mode shift assembly
Planetary gear set
Input shaft
Rear output shaft
Drive chain
Range shift assembly
Front output shaft

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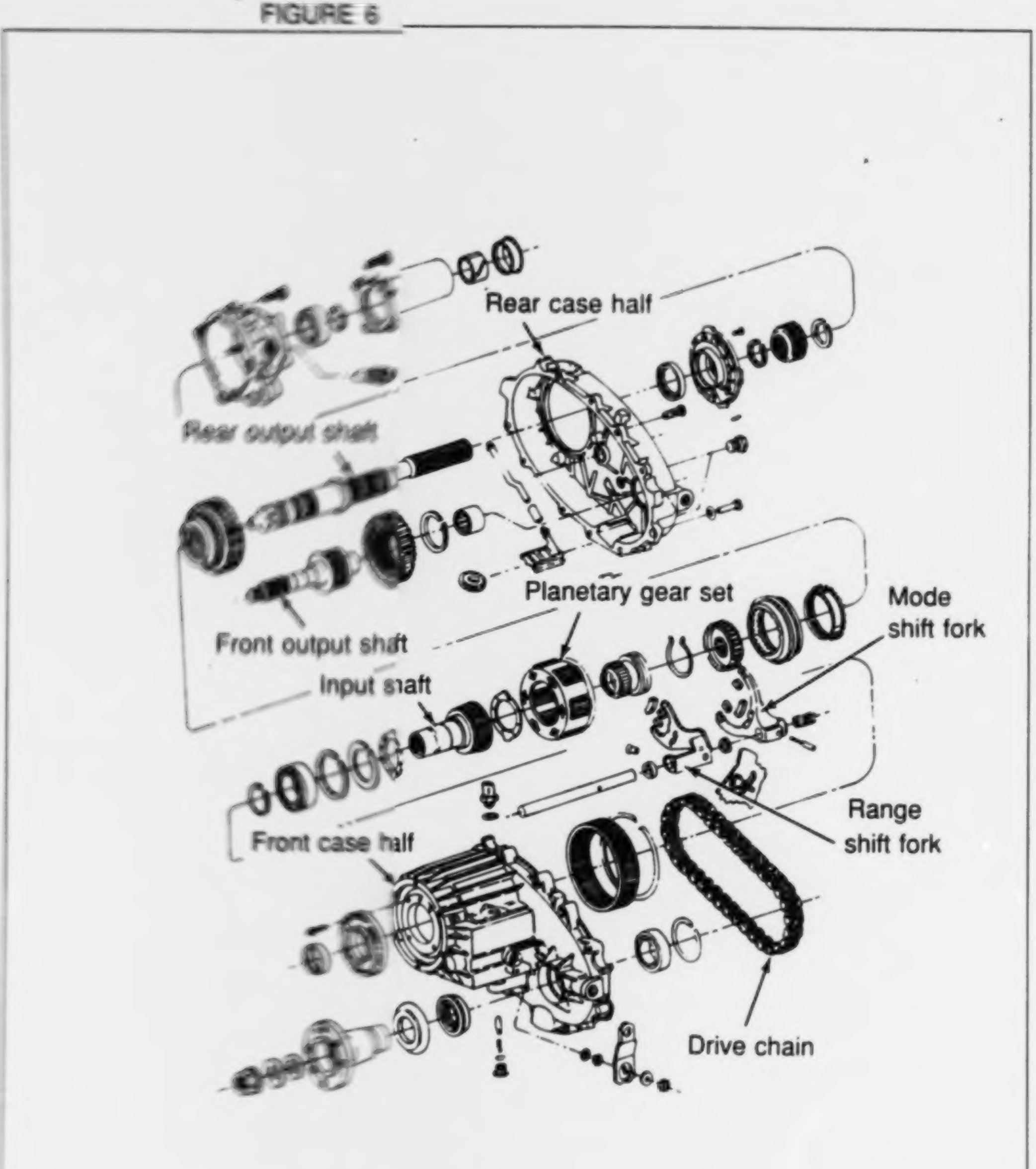
NOTE: A ***part-time transfer case*** can transfer torque *either* to the rear drive axles (2-wheel drive) *or* to both the front and the rear drive axles (4-wheel drive). When the transfer case is in 2-wheel drive, no torque at all is sent to the front drive axles. Part-time transfer cases are usually found on trucks rather than cars. The transfer case shown is a ***part-time chain-driven transfer case***—torque is carried to the transfer case's front output shaft by a chain drive. A planetary gear set in this transfer case allows for an additional gear change to increase power when the vehicle is in four-wheel drive. (See Objective 4.) A part-time transfer case has no third differential since power adjustments between the front and rear axles can be made manually. Notice that the transfer case shown has both a range shift fork (which allows for the power change from high to low) and a mode shift fork (which allows for shifting between 2-wheel and 4-wheel drive). This is the most common type of transfer case.

EXAMPLE:

FIGURE 6


Rear case half
Rear output shaft
Planetary gear set
Mode shift fork
Front output shaft
Input shaft
Range shift fork
Front case half
Drive chain

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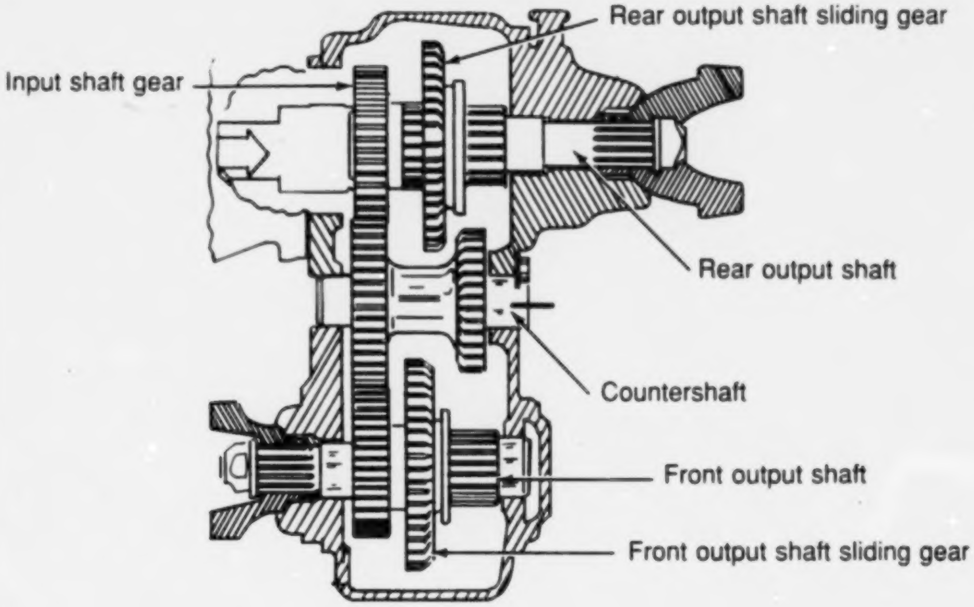
PART-TIME GEAR-DRIVEN TRANSFER CASE

FIGURE 7



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OPERATION OF A GEAR-DRIVEN TRANSFER CASE

Gear-driven transfer cases use a countershaft and a sliding gear on both the front and rear output shafts to transfer the torque. The gear shown is set in neutral. The input shaft gear, the countershaft gear, and the output shaft gear are all turning, but they are not splined to the rear and the front output shafts and so the output shafts are not turning.

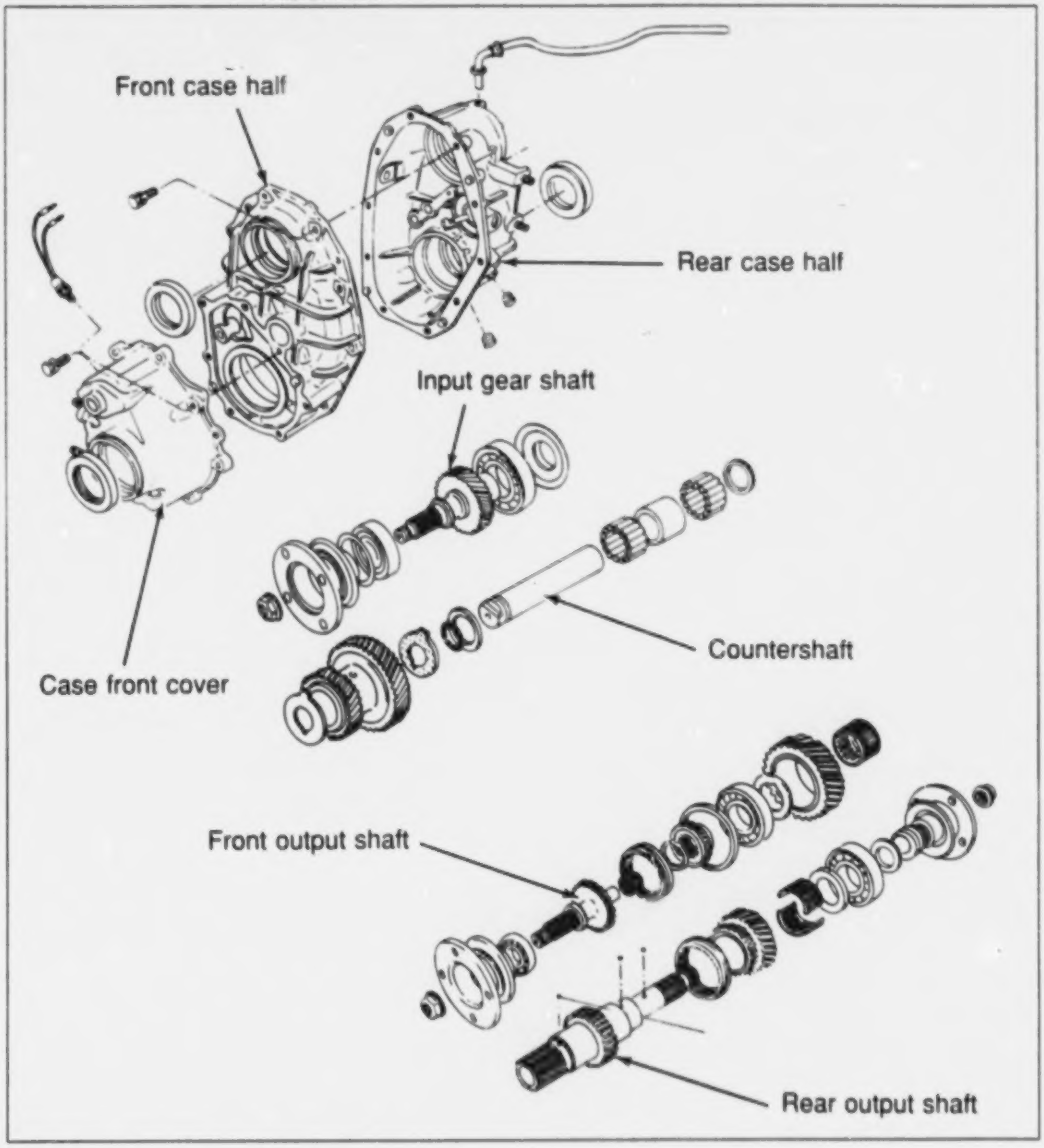
Two-wheel high — During two-wheel drive, the sliding gear on the rear output shaft is moved forward to connect the input shaft gear to the rear output shaft. This allows the torque to transfer directly to the rear output shaft.

Four-wheel high — For four-wheel high, *both* the front and the rear output shaft sliding gears move forward and both output shafts now carry torque.

Four-wheel low — To allow for four-wheel low operation, both sliding gears move back and engage the rearward gear on the countershaft. Notice that the diameter of this gear is smaller than the front gear. This smaller diameter allows the power increase. (Remember: If the driven gear is smaller than the driving gear, the power is *increased*.)

EXAMPLE:

FIGURE 8

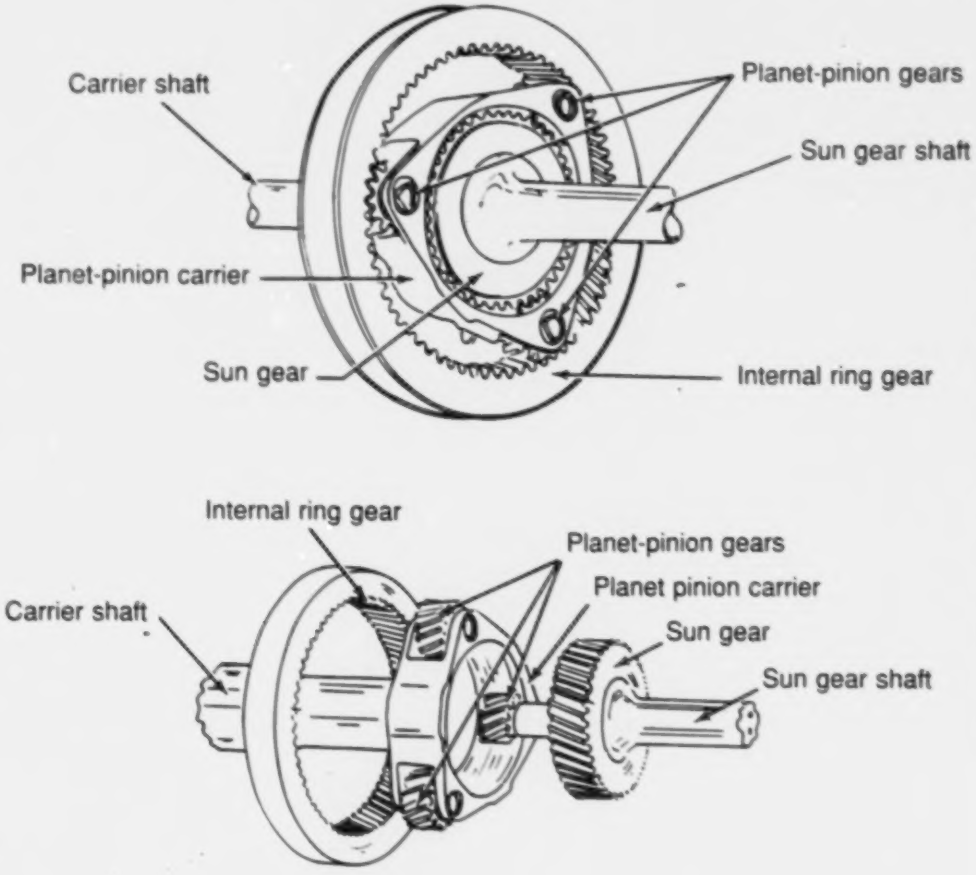

Front case half
Rear case half
Input gear shaft
Countershaft
Case front cover
Front output shaft
Rear output shaft

Used with permission of Nissan Motor Co., LTD.

NOTE: A **part-time gear-driven transfer case** allows the vehicle to be used with either 2-wheel or 4-wheel drive, but in this type of case torque is transferred to the front output shaft by a gear assembly rather than by a chain drive. A vehicle with a part-time gear-driven transfer case has to come to a complete stop before it can be changed from 2- to 4-wheel drive.

OBJECTIVE 5 **Match the names of the parts of a planetary gear assembly to illustrations.**

FIGURE 9


Carrier shaft
Planet-pinion gears
Sun gear shaft
Planet-pinion carrier
Sun gear
Internal ring gear
Internal ring gear
Planet-pinion gears
Carrier shaft
Planet pinion carrier
Sun gear
Sun gear shaft

NOTE: A simple planetary gear assembly has three main parts: (1) a ***sun gear*** machined on the end of a shaft, (2) a ***carrier assembly***, which consists of the ***planet pinion carrier***, the ***carrier shaft***, and two or more ***planet-pinion gears***, and (3) an ***internal ring gear***.

HOW A PLANETARY GEAR CHANGES TORQUE SPEED AND POWER

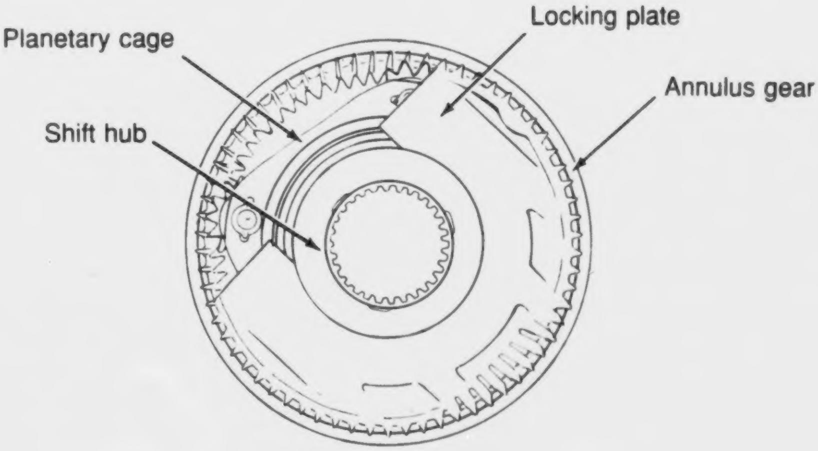
In a transfer case, it is the ***planetary gear assembly*** that uses gears to increase the power of the torque coming from the transmission.

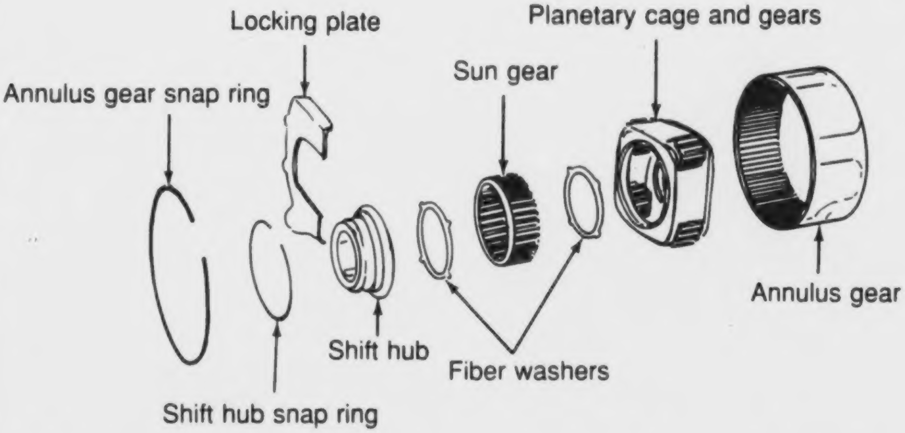
LOW SETTING - The torque from the sun gear shaft rotates the sun gear. The rotating sun gear turns the planet-pinion gears, which begin to walk around the inside of the internal gear. As the planet-pinion gears walk around the internal gear, the rest of the carrier assembly—the carrier and the carrier shaft—also turns. The carrier shaft will turn slower than the sun shaft because the circumference of the internal gear is larger than the circumference of the sun gear: the sun gear must turn more than once in order to turn the carrier and its shaft once. A decrease in torque speed results in an increase in torque power.

HIGH SETTING - However, if the sun gear and the carrier assembly are locked together, they will rotate in a direct 1:1 ratio and the carrier shaft will rotate at exactly the same speed as the sun shaft. This is exactly what happens when a four-wheel drive vehicle is set at HIGH. The drivetrain of a four-wheel drive vehicle will deliver more power if the transfer case is set at LOW, and will deliver more speed if set at HIGH.

PLANETARY GEAR ASSEMBLY IN A TRANSFER CASE

The following illustrations show a typical planetary gear assembly used in a transfer case. The shift hub and locking plate are used to lock the sun gear and planetary carrier when the transfer case is set at HIGH. Notice that the carrier has four planet-pinion gears. This increases the strength of the assembly by distributing the load.


Locking plate
Planetary cage
Annulus gear
Shift hub


Locking plate
Planetary cage and gears
Sun gear
Annulus gear snap ring
Annulus gear
Shift hub
Fiber washers
Shift hub snap ring

Adapted with permission of Ford Motor Company.

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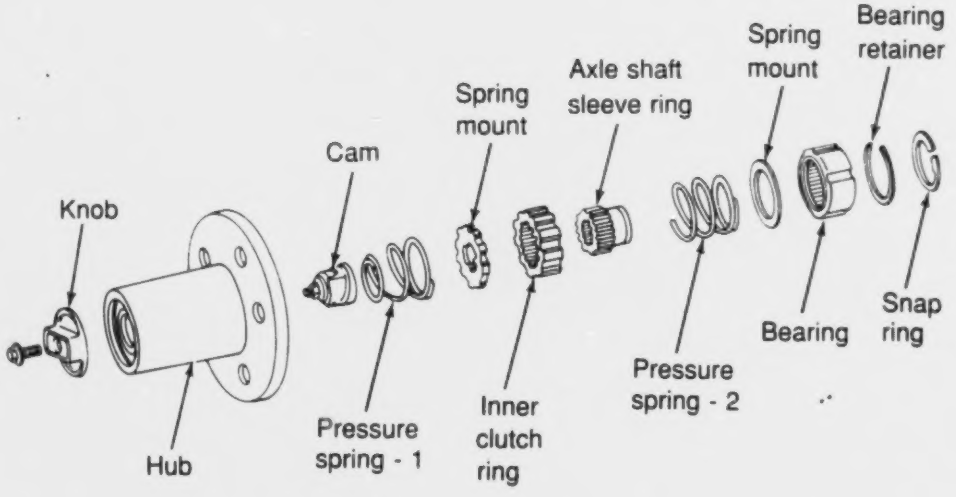
OBJECTIVE 6 **List three ways the front drive wheels can be disconnected in a four-wheel drive vehicle.**

- **MANUAL LOCKING HUBS**

EXAMPLE:

FIGURE 10


Bearing retainer
Spring mount
Axle shaft sleeve ring
Spring mount
Cam
Knob
Snap ring
Bearing
Pressure spring - 2
Inner clutch ring
Pressure spring - 1
Hub

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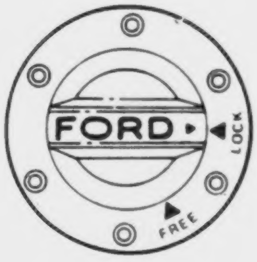
The driver must get out of the vehicle and lock and unlock ***manual locking hubs*** by hand before shifting into four-wheel drive. Manual locking hubs have two positions—*LOCK* and *FREE*. In the *LOCK* position, the wheel hubs are locked to the front drive axle and can be turned by the power coming through the front drivetrain. In the *FREE* position the hubs are not locked to the axles and turn freely and independently.


FORD
LOCK
FREE

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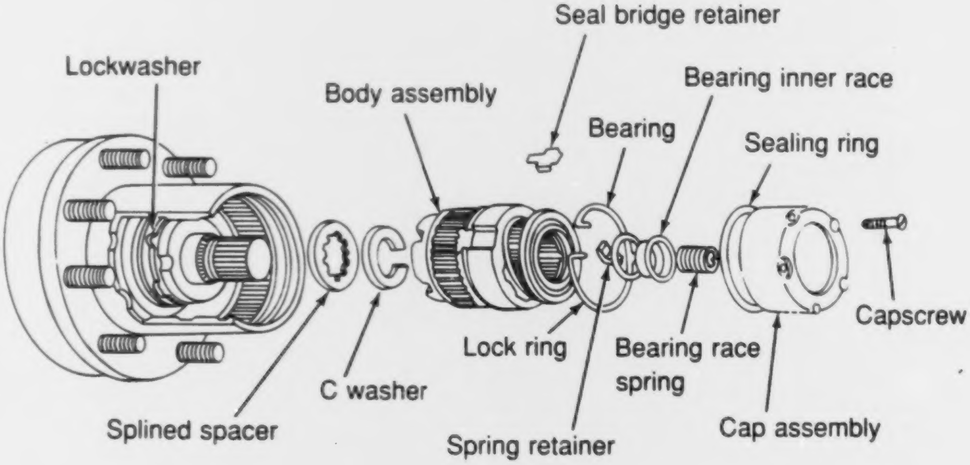
- **AUTOMATIC LOCKING HUBS**

  EXAMPLE:

FIGURE 11


Seal bridge retainer
Lockwasher
Body assembly
Bearing inner race
Bearing
Sealing ring
Capscrew
Lock ring
Bearing race spring
C washer
Splined spacer
Spring retainer
Cap assembly

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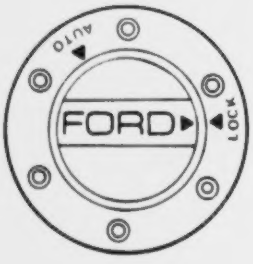
Automatic locking hubs will immediately lock to the drive axles whenever the vehicle is operating in four-wheel drive. The clutch action in the automatic hubs allows the axles to drive the wheels but the wheels cannot drive the axles. But using automatic locking hubs has two disadvantages in four-wheel drive operation: (1) the front wheels cannot power the vehicle when backing up, and (2) the front wheels cannot be used for compression braking when the vehicle is going down hill. To make up for these disadvantages, many automatic locking hubs can also be locked manually.

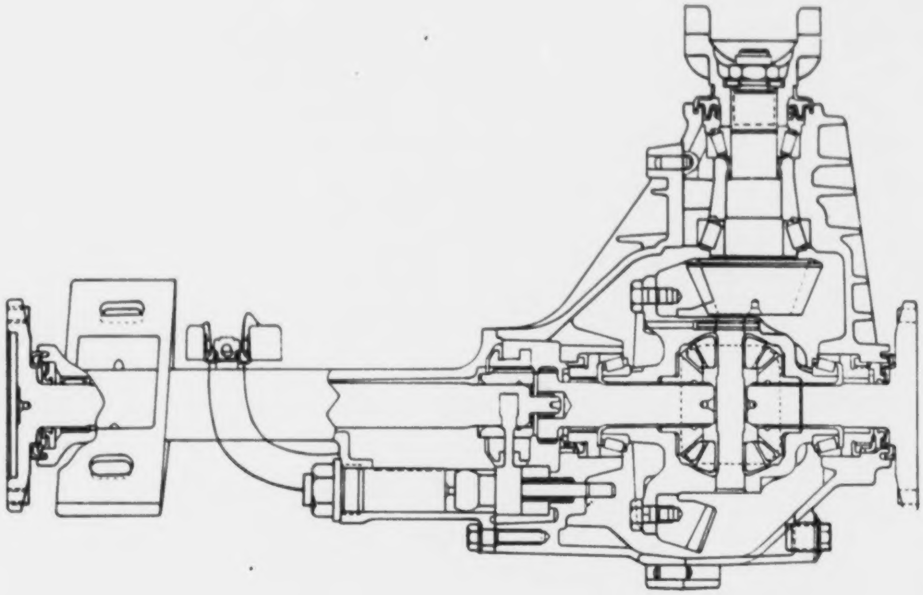

AUTO
FORD
LOCK

Used with permission of Ford Motor Company.

- **FRONT AXLE DISCONNECT MECHANISM**

EXAMPLE:

FIGURE 12



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Some vehicles have a special **front axle disconnect mechanism** built into their front drive axle assembly which allows one of the front drive axles to be connected and disconnected automatically. The other drive axle is still connected to the front differential. The disconnect mechanism shown is activated electrically whenever the vehicle is shifted into four-wheel drive; other front axle disconnect mechanisms are operated by a vacuum motor. (See Job Sheet 1, Figure 4.) A vehicle operating with a front axle disconnect mechanism does not save as much fuel and wear-and-tear as one using locking hubs, but it still makes a substantial fuel savings—and many manufacturers believe its convenience more than makes up for the loss.

WHY DO THE FRONT WHEELS NEED TO BE DISCONNECTED?

A vehicle with ***part-time four wheel drive*** is designed to operate as either a two-wheel or a four-wheel drive vehicle. When the vehicle is operating in four-wheel drive, both the front and the rear axles are receiving torque, driving all four drive wheels.

However, when the vehicle is operating in two-wheel drive, only the rear axle and wheels are driving the vehicle. The front wheels, axle, differential, and driveline are disconnected from engine torque. But this does not mean they are not moving—they are. The front wheels are turning because they are attached to the moving vehicle, and because the rotating front wheels are connected to the rest of the front-wheel drivetrain, the *front wheels* will turn the front axle, differential, and front driveline.

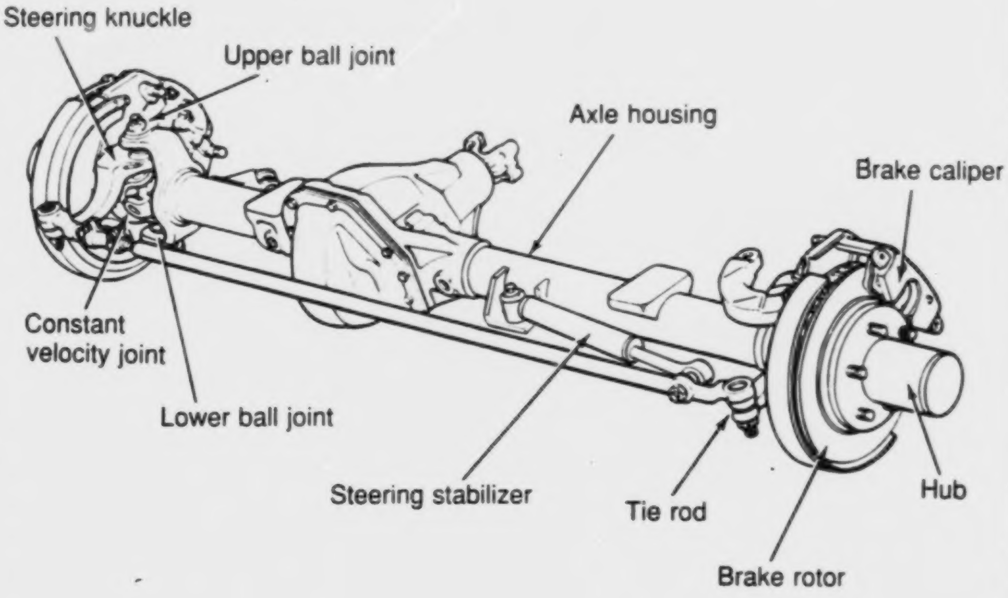
It takes a lot of extra energy—and fuel—to turn all these additional components. And because the components are turning, their parts get a lot of additional, unnecessary wear. To improve fuel economy and reduce wear on the front driveline, differential, and drive axles, automotive designers install methods of disconnecting the front wheels while the vehicle is operating in two-wheel drive.

Full-time four-wheel drive vehicles do not normally use locking hubs or front axle disconnect mechanisms. However, some drivers equip the front wheels on their full-time four-wheel drive vehicle with manual locking hubs after they purchase it. When they set the hubs in the free position, the vehicle's front drive axle still rotates, but the freed hubs disconnect the power from the front drive wheels.

OBJECTIVE 7 **Label the major types and parts of *front drive axle* assemblies used on four-wheel drive vehicles on illustrations.**

SOLID FRONT AXLE ASSEMBLY

FIGURE 13


Steering knuckle
Upper ball joint
Axle housing
Brake caliper
Constant velocity joint
Lower ball joint
Steering stabilizer
Tie rod
Hub
Brake rotor

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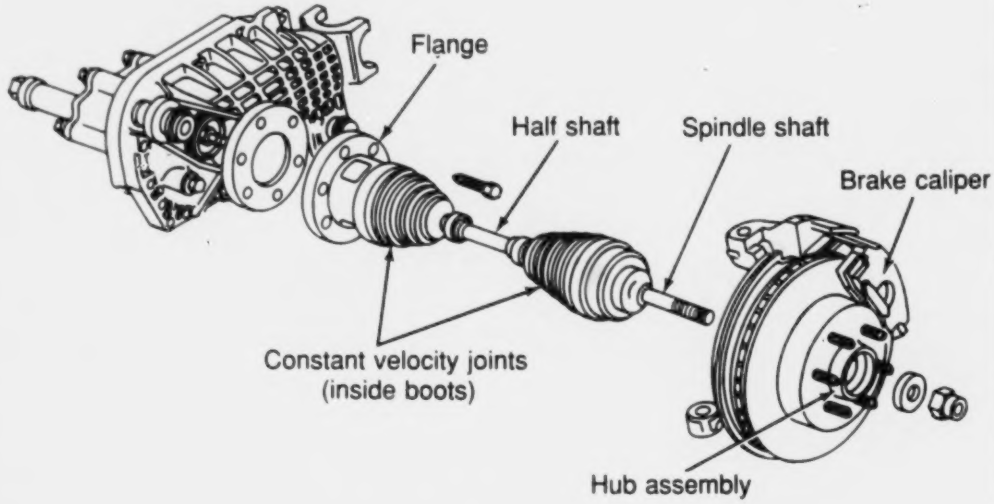
NOTE: A ***solid front axle assembly*** has a universal joint only at the outboard end of each axle and is contained in an axle housing. Similar to a rear drive axle, instead of being connected to a wheel hub, the universal joint on the outboard end of the axle is connected to a steering knuckle which allows the front wheel to steer. As in a rear drive axle, a solid front axle is mounted to the front suspension, and a slip joint on the front driveline allows for the movement of the axle.

INDEPENDENT FRONT AXLE ASSEMBLY

FIGURE 14


Flange
Half shaft
Spindle shaft
Brake caliper
Constant velocity joints
(inside boots)
Hub assembly

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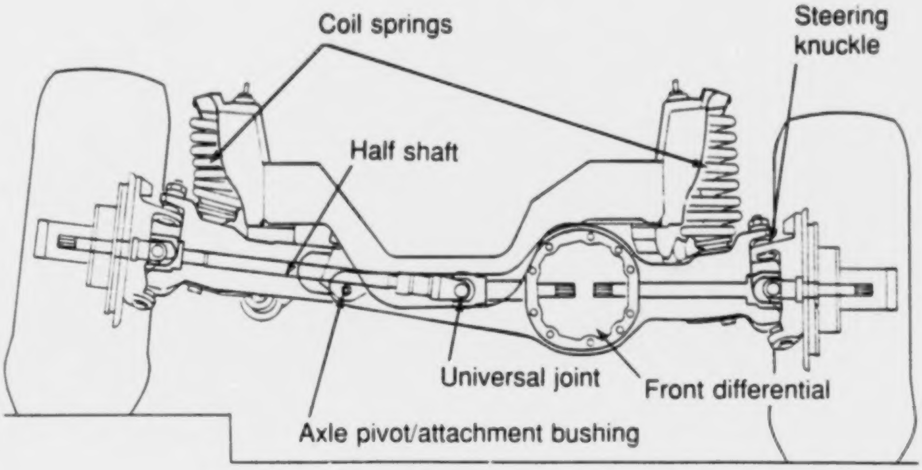
NOTE: An ***independent front axle assembly*** typically has constant velocity joints at both ends of each half shaft and is not contained in an axle housing. This is the same type of axle that is used with transaxles. (See Objective 4, Unit 5.) This type of front drive axle allows the differential to be mounted to the vehicle frame while the axles, mounted to drive knuckles and the suspension, respond individually to road conditions. Several designs using half shafts and universal joints are in use. (See the example on the next page.)

EXAMPLE:

FIGURE 15


Coil springs
Steering knuckle
Half shaft
Universal joint
Front differential
Axle pivot/attachment bushing

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Some independent front axle assemblies do not have constant velocity joints at the differential.

FOUR-WHEEL DRIVE TROUBLESHOOTING GUIDE

In addition to the vehicle's service manual, use Supplement 2, ***Transfer Case Noise, Leak, and Performance Diagnosis Chart***, to assist in diagnosing front-wheel drive problems.

1. **Talk to the vehicle's owner.** The first step in diagnosing any automotive problem is to talk to the vehicle's owner about the nature of the problem and the service history of the vehicle. What problems are there in shifting? What gears are noisy? Under what conditions does the problem occur?

2. **Identify the four-wheel drive components in the vehicle.** Because of the variety of designs used for four-wheel drive vehicles, it is not always obvious what special components are present in each model. Is the transfer case built into the transmission? Is there a third driveline to the transfer case? Are there locking hubs? Are they manual or automatic? What kind of shift linkage is used? Is there a front axle disconnect mechanism? If you don't already know the answers to questions like these, find the answers before you begin any diagnostic efforts.

3. **Road test the vehicle to verify the problem.** Use Supplement 3, Unit 1, "Making a Diagnostic Road Test," to road test the vehicle. Make sure all fluid levels are correct before you begin. Drive in a quiet area and try to reproduce the problems and noises described to you by the owner. The purpose of this road test should be to verify the problem and to try to determine the exact nature of the problem or where the noise you are hearing is coming from. Use Supplement 2, "Transfer Case Noise, Leak, and Performance Diagnosis Chart," to help identify common problems.

4. **Make a visual inspection.** Examine the four-wheel drive systems used in the vehicle: the shift linkage, transfer case, viscous coupling, locking hubs, front axle disconnect mechanism, etc. Check the components against the service manual; look for wear, damage, leaks, and loose or missing parts. Check the tire sizes and gear ratios for possible mismatching.

5. **Consider problems with related drivetrain components.** Troubleshooting four-wheel drive systems also involves diagnosing problems that may originate in other parts of the drivetrain. Front and rear drivelines, front and rear differentials, and front and rear driving axles are only some of the possible trouble spots. Use the vehicle's service manual and the troubleshooting guidelines for other drivetrain components found in this manual to help you narrow down the source of the noise or performance problems. Problems that originate in other parts of the drivetrain are diagnosed just like problems in a two-wheel drive vehicle.

6. **Check electrical systems.** Components on many four-wheel drive vehicles are operated electrically. The first step in troubleshooting these systems is to check the system fuse(s). If the fuse is in good condition, check the bulb, socket, and wiring for the system controls. The vehicle's service manual will provide a circuit diagram and troubleshooting guidelines. Follow the procedures given to diagnose electrical problems in four-wheel drive components.

7. **Check vacuum systems.** If there are vacuum systems used for the four-wheel drive, obtain the vacuum diagrams and check the condition of the hoses and other components for wear and damage.

8. **Test the viscous coupling.** If the vehicle has a viscous coupling, it can be tested on the vehicle by following these steps:

   (1) Park on level ground.
   (2) Shift the transfer case into the high four-wheel drive setting.
   (3) Shift the transmission into neutral.
   (4) Turn off the engine.
   (5) Jack up one front wheel until it is off the ground.
   (6) Remove the hubcap and position a torque wrench on one lug nut.
   (7) Rotate the wheel with the torque wrench and note the torque necessary *to keep the wheel rotating.*

   If the torque reading is less than 45 ft.-lbs. (or the manufacturer's specification), the transfer case should be disassembled and the viscous coupling tested again.

   (1) Remove the viscous coupling from the transfer case.
   (2) Assemble the clutch gear and side gear and install them into the viscous coupling.
   (3) Clamp the side gear into a soft-jawed vise.
   (4) Install the rear output shaft and yoke.
   (5) Install the yoke retaining nut.

(6) Position the torque wrench on the yoke retaining nut and rotate the output shaft.

(7) If the yoke retaining nut registers more than 25 ft.-lbs. (or the manufacturer's specification) of torque before it begins rotating the output shaft, replace the viscous coupling.

9. **Diagnose and repair the four-wheel drive components.** Once you have made a diagnosis, use the vehicle's service manual and the job sheets in this unit to remove and disassemble the components involved. Your inspection and repair during this last step should confirm and correct the problems. A final test drive should always be made to make sure the problems have been eliminated.

TRANSFER CASE
NOISE, LEAK, AND PERFORMANCE DIAGNOSIS CHART

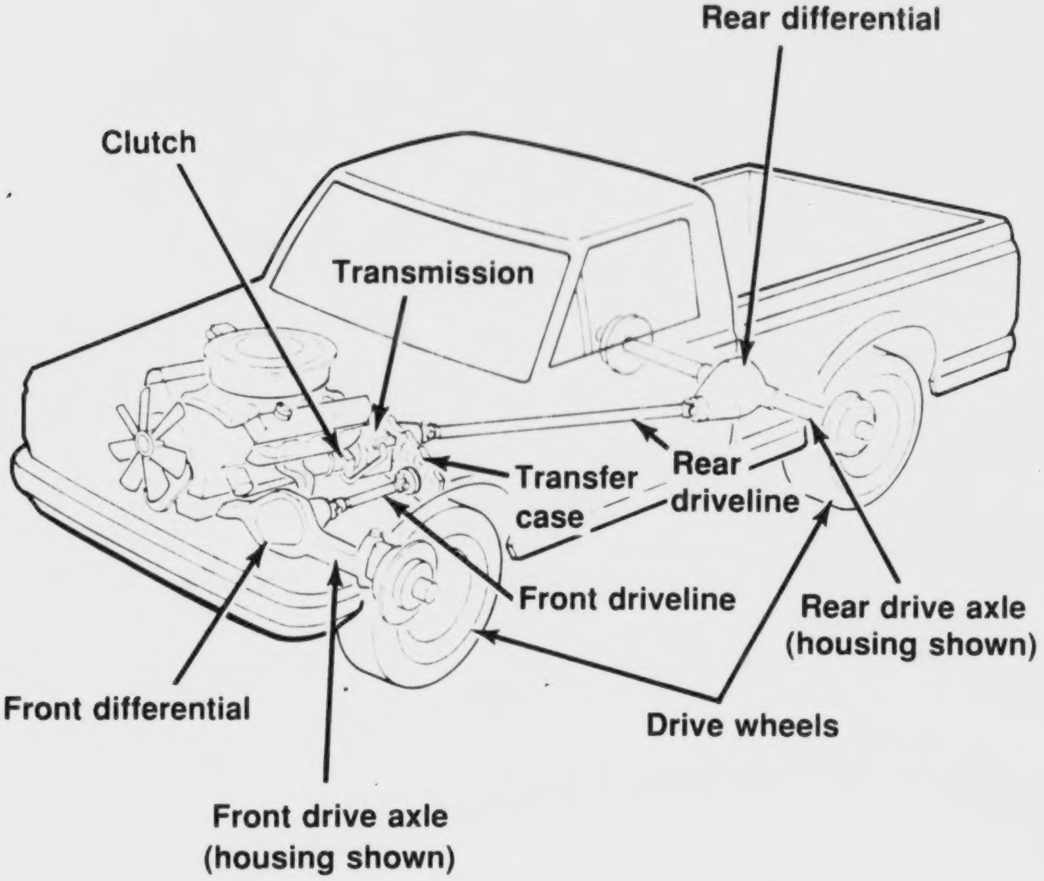
Causes that are more probable are listed first.

CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Noise	Worn or damaged bearing	Replace bearing
	Worn or damaged chain	Replace chain
	Low lubricant level	Add lubricant as needed
	Incorrect lubricant	Drain and replace with correct lubricant
	Transfer case not completely engaged in proper range	Stop and reshift
	Gear damage	Replace damaged gear
	Damaged clutch hub or gear teeth	Replace clutch hub and/or gear teeth
	Loose yoke bolts	Torque to specifications
	Loose adapter bolts	Torque to specifications
	Worn or damaged shift linkage components	Replace worn or damaged parts
	Misalignment of drivelines or universal joints	Align correctly
	Shift linkage loose or binding	Tighten, lubricate, or replace parts as necessary
Transfer case jumps out of gear	Improperly adjusted shift linkage	Adjust shift linkage
	Transfer case not completely engaged in proper range	Stop and reshift
	Damaged clutch hub or gear teeth	Replace clutch hub and/or gear teeth

TRANSFER CASE NOISE, LEAK, AND PERFORMANCE DIAGNOSIS CHART (CONTINUED)

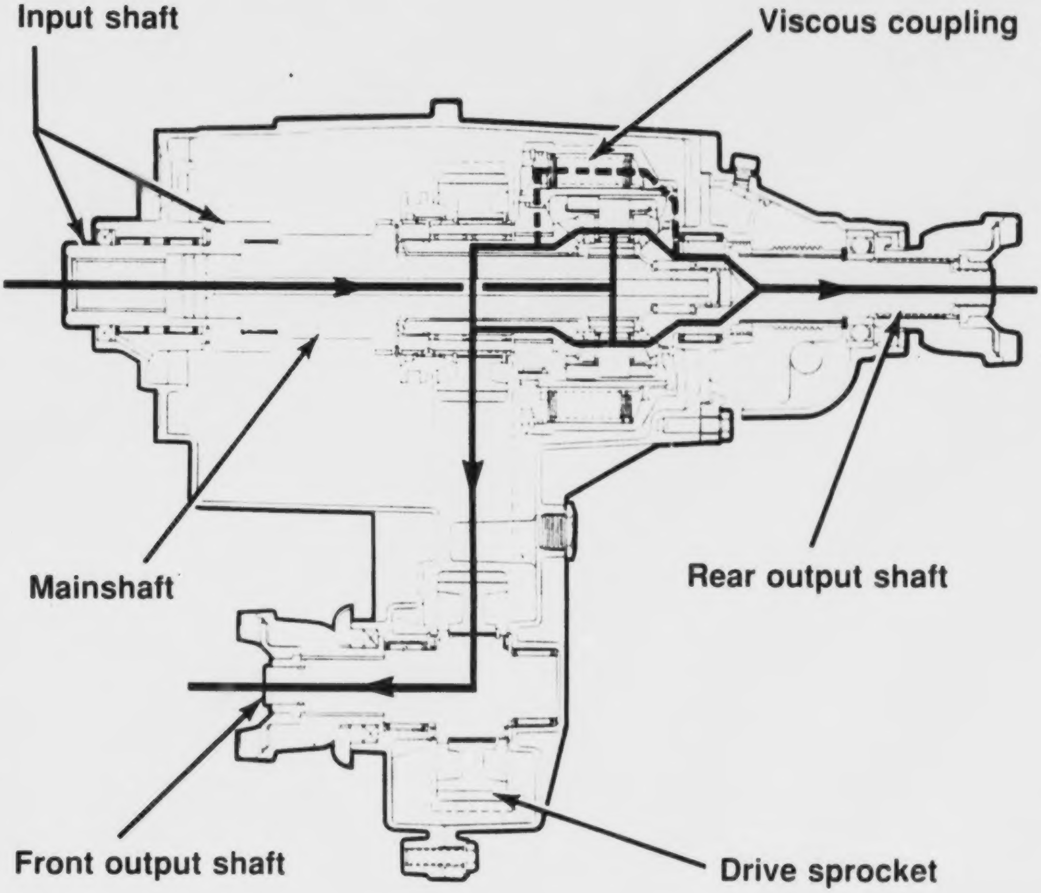
CONDITION	POSSIBLE CAUSES	CORRECTIVE ACTION
Transfer case jumps out of gear (continued)	Shift linkage loose or binding	Tighten, lubricate, or replace parts as necessary
	Loose transfer case mounts	Tighten mounts
	Worn or damaged shift linkage components	Replace worn or damaged parts
	Loose slip joints on front and/or rear output shafts	Inspect and replace slip joint or output shaft
Gears disengage from position	Misadjusted or loose shift linkage	Adjust and tighten
	Missing detent ball or spring	Replace ball or spring
	Bent shift rod	Replace shift rod
	Worn or damaged gears	Replace gears
Shift lever difficult to move	Dirty or contaminated shift linkage	Clean and lubricate
	Shift linkage outside the case is binding	Inspect, lubricate, and replace parts as needed
	Vehicle speed too great to permit shifting	Consult owner's manual and shift appropriately
	Insufficient or incorrect lubricant	Check and correct lubricant type and level
	Shift components binding inside the transfer case	Inspect, lubricate, and replace parts as needed
Lubricant leak	Too much lubricant	Adjust lubricant level
	Leaking seals or gaskets	Replace seals or gaskets
	Scored yoke sealing area	Refinish or replace
	Vent closed or obstructed	Clear and replace vent if necessary
	Loose bolts	Torque to specifications
Abnormal tire wear	Extended operation on hard, dry surface roads in 4H range	Operate in 2H on hard surface roads

Four-Wheel Drivetrain


Rear differential
Clutch
Transmission
Transfer case
Rear driveline
Front driveline
Rear drive axle (housing shown)
Front differential
Drive wheels
Front drive axle (housing shown)

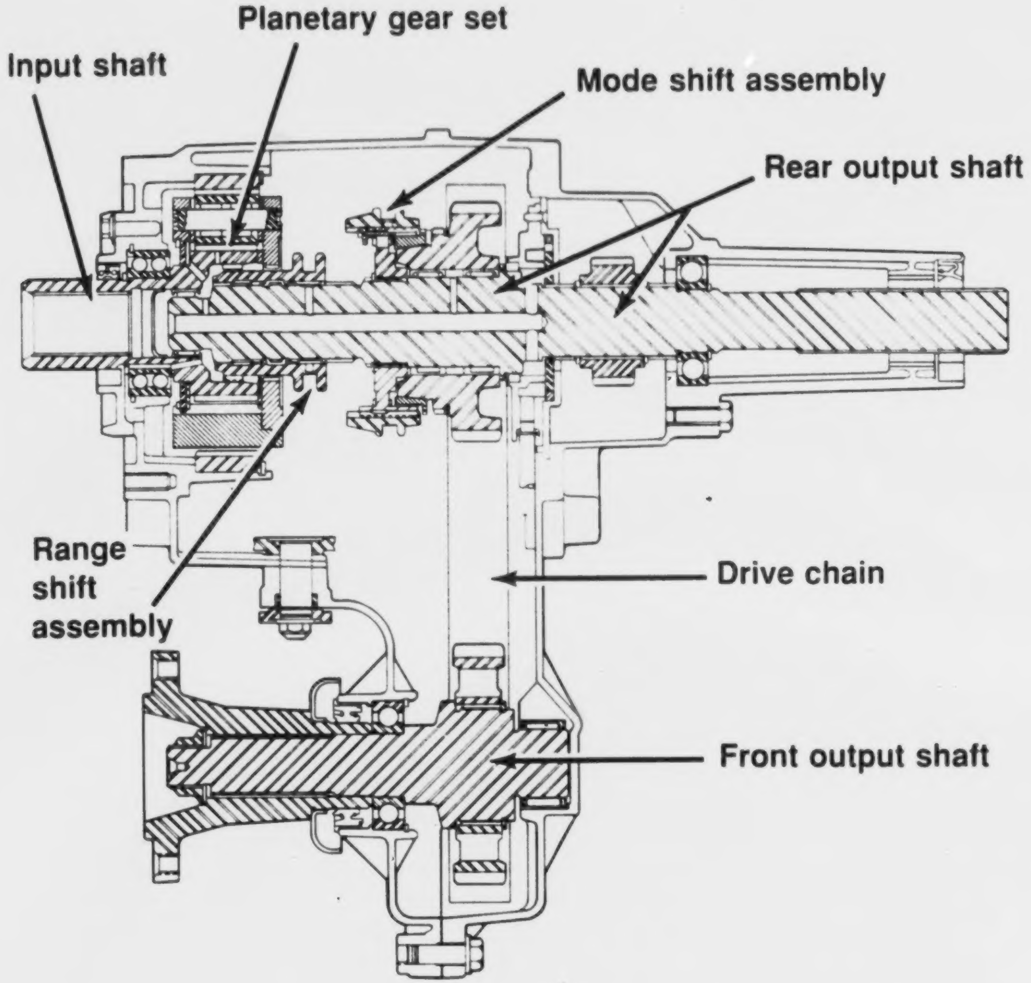
Used with permission of Ford Motor Company

Full-Time Transfer Case


Input shaft
Viscous coupling
Mainshaft
Rear output shaft
Front output shaft
Drive sprocket

Used with permission of Chrysler Corporation

Part-Time Chain-Driven Transfer Case


Planetary gear set
Input shaft
Mode shift assembly
Rear output shaft
Range shift assembly
Drive chain
Front output shaft

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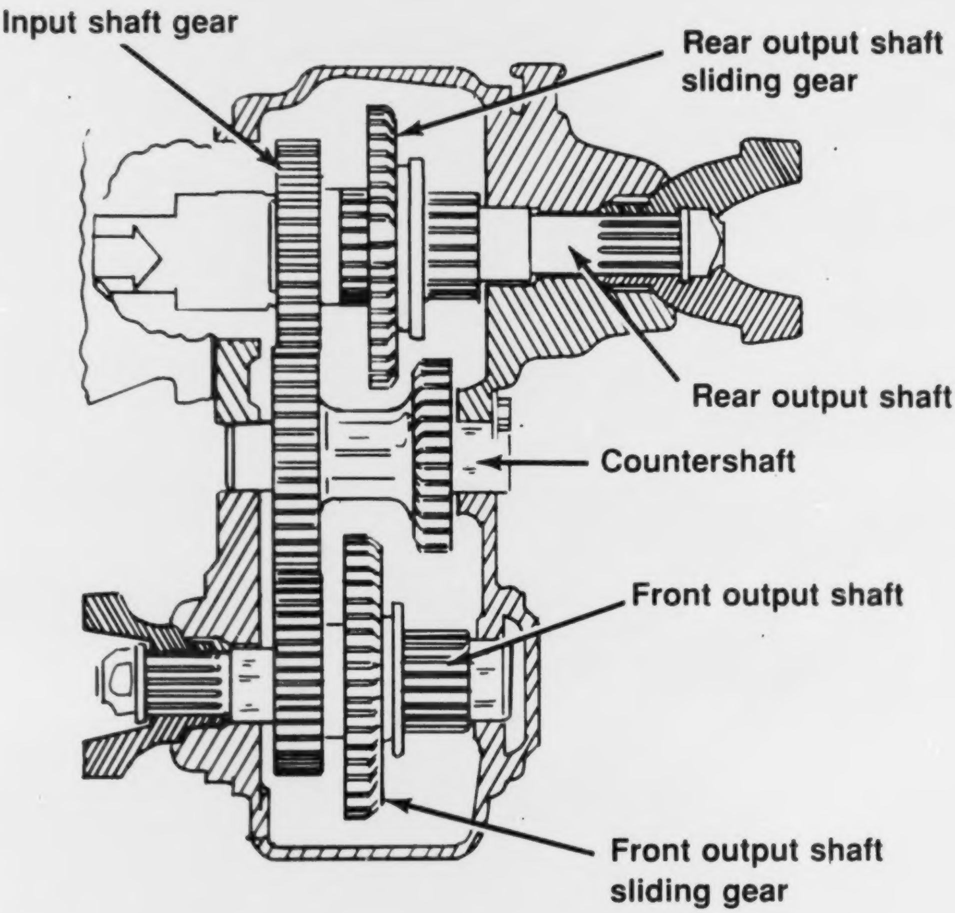
Part-Time Gear-Driven Transfer Case


Input shaft gear
Rear output shaft sliding gear
Rear output shaft
Countershaft
Front output shaft
Front output shaft sliding gear

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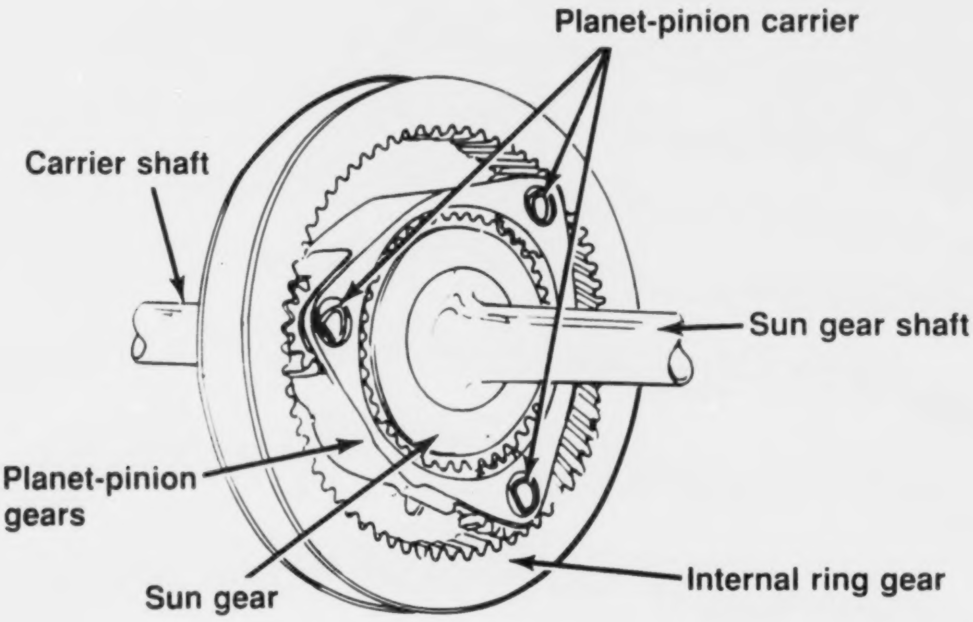
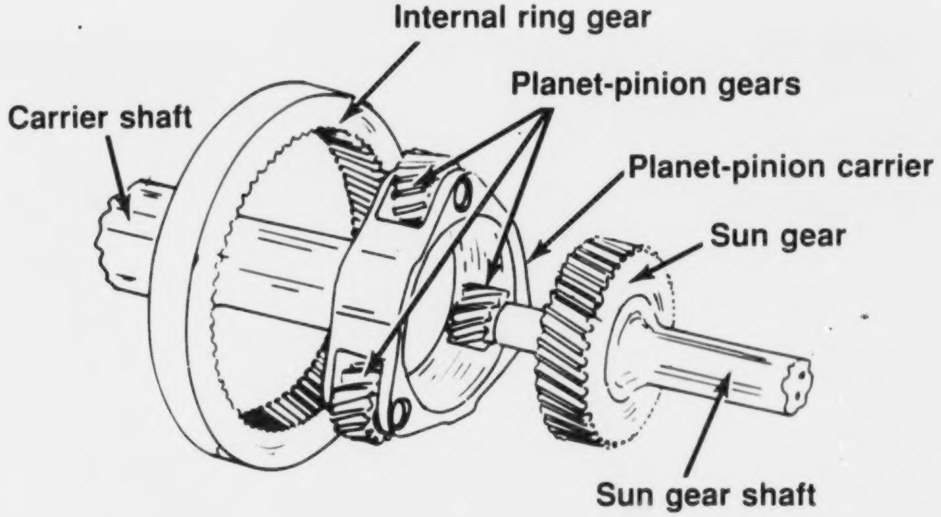
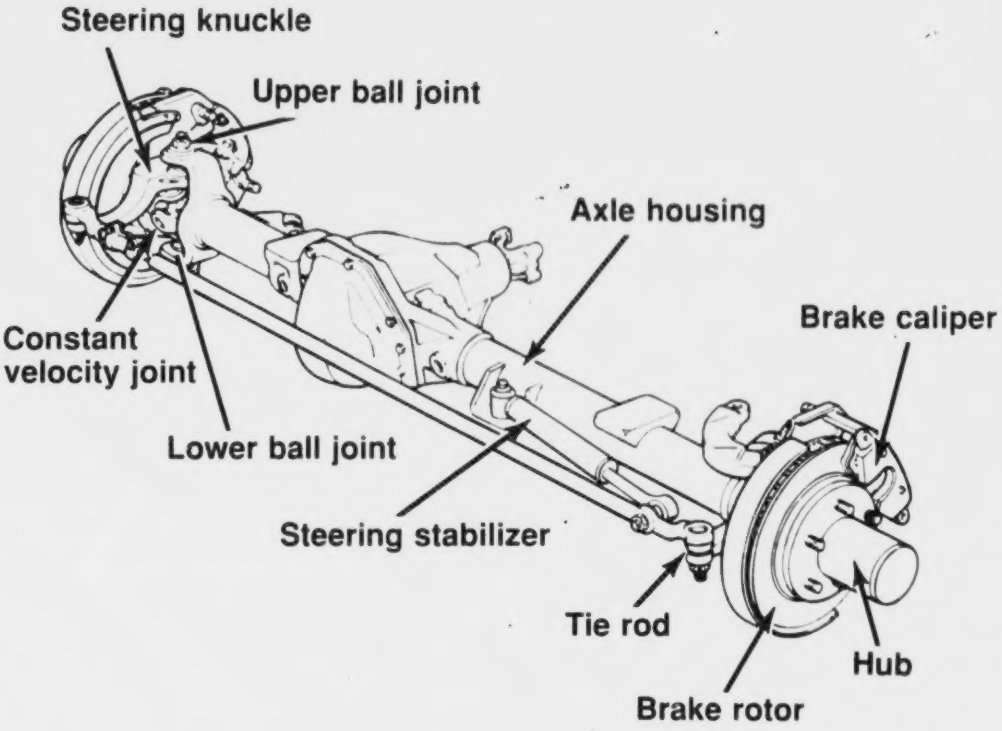
Planetary Gear Assembly


Planet-pinion carrier
Carrier shaft
Sun gear shaft
Planet-pinion gears
Sun gear
Internal ring gear


Internal ring gear
Carrier shaft
Planet-pinion gears
Planet-pinion carrier
Sun gear
Sun gear shaft

Solid Front Axle Assembly


Steering knuckle
Upper ball joint
Axle housing
Brake caliper
Constant velocity joint
Lower ball joint
Steering stabilizer
Tie rod
Hub
Brake rotor

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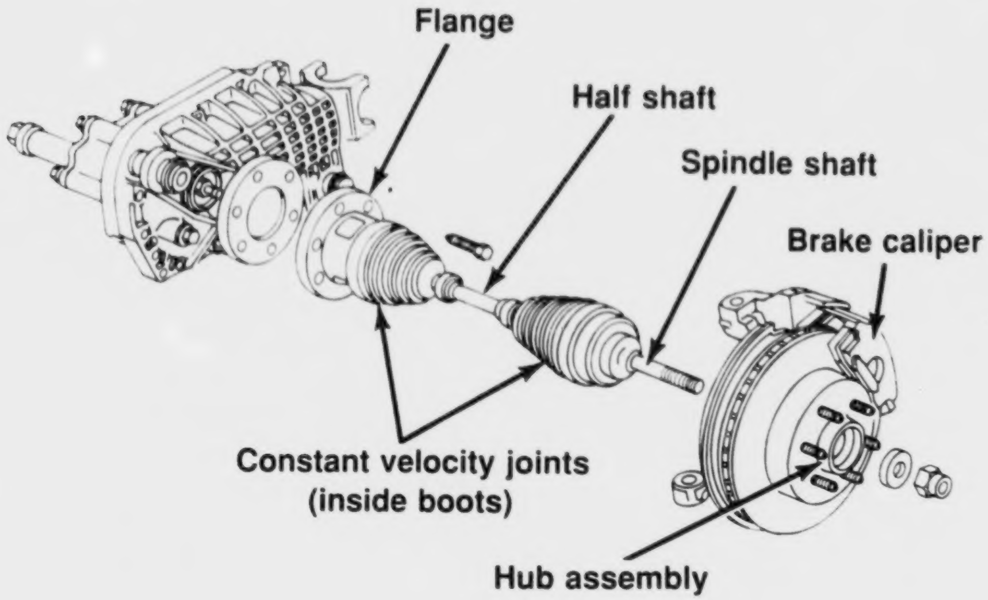
Independent Front Axle Assembly


Flange
Half shaft
Spindle shaft
Brake caliper
Constant velocity joints
(inside boots)
Hub assembly

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ASSIGNMENT SHEET 1

SERVICE FOUR-WHEEL DRIVE VI

NAME ______________________________ SCORE ________

OBJECTIVE 8

Diagnose four-wheel drive assembly noise, vibration, and performance problems.

INTRODUCTION

Diagnosing problems related to four-wheel drive vehicles centers mainly around problems with the transfer case. Problems relating to other four-wheel drive drivetrain components are diagnosed the same way they are on a two-wheel drive vehicles. The vehicle's service manual and the troubleshooting guides for the driveline, differential, clutch, transmission, and transaxle found in previous units will help with this type of diagnosis.

Use Supplements 1 and 2, ***Four-Wheel Drive Troubleshooting Guide***, and ***Transfer Case Noise, Leak, and Performance Diagnosis Chart***, to assist in diagnosing transfer case problems.

DIRECTIONS

Study the Supplements mentioned just above, and then read each of the following questions carefully. Select the answer for each that is *most* correct. Write the correct letter in the blank.

______1. The most common cause of a leak in a transfer case is:

A. Loose bolts
B. Too much lubricant
C. Obstructed vent
D. Leaking seals or gaskets

______2. Which of the following steps should be taken first when troubleshooting a problem with a four-wheel drive vehicle?

A. Check the electrical systems
B. Road test the vehicle
C. Identify the four-wheel drive components in the vehicle
D. Test the viscous coupling

_____3. The tires on a four-wheel drive vehicle are wearing more than they would on a two-wheel drive vehicle. Technician A says that this is an indication of improperly adjusted locking hubs. Technician B says that it is more likely that the driver has been operating the vehicle in four-wheel drive on dry paved roads. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____4. In testing a viscous coupling while it is still in the vehicle, the amount of torque necessary to keep the wheel rotating should be more than:

A. 25 ft.-lbs.
B. 30 ft.-lbs.
C. 40 ft.-lbs.
D. 45 ft.-lbs.

_____5. Which of the following problems might result from having insufficient or incorrect lubricant in the transfer case?

A. Lubricant leak
B. Abnormal tire wear
C. Transfer case jumps out of gear
D. Shift lever difficult to move

_____6. Technician A says that most drivetrain components in a four-wheel drive vehicle are diagnosed and repaired just as they would be in a two-wheel drive vehicle. Technician B says that diagnosis and repair of all drivetrain components in a four-wheel drive vehicle are different than performing the same procedures on a two-wheel drive vehicle. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

_____7. The first step in diagnosing problems with electrical systems in a four-wheel drive vehicle is:

A. Check the vehicle schematic
B. Check the fuse(s)
C. Check the system control bulb
D. Check the wiring

______8. Which of the following steps in the troubleshooting process is **not necessarily** made on every four-wheel drive vehicle?

A. Road test
B. Visual inspection
C. Talk to the owner
D. Test the viscous coupling

______9. Which of the following is probably **not** the cause of noise in a part-time gear driven transfer case?

A. Worn or damaged bearing
B. Worn or damaged chain
C. Low lubricant level
D. Gear damage

_____10. Which of the following could cause transfer case gears to disengage from position?

A. Misadjusted or loose shift linkage
B. Loose yoke bolts
C. Excessive vehicle speed
D. Too much lubricant

ASSIGNMENT ANSWERS

SERVICE FOUR-WHEEL DRIVE

VI

ASSIGNMENT SHEET 1

1. B
2. C
3. B
4. D
5. D
6. A
7. B
8. D
9. B
10. A

JOB SHEET 1

SERVICE FOUR-WHEEL DRIVE VI

OBJECTIVE 9A **Inspect, adjust, and repair transfer case shifting components.**

INTRODUCTION

A transfer case can be shifted manually or electrically. (See Figures 1 & 2.) Inside the vehicle, the driver shifts by pushing a button, moving a lever on a console, or shifting a floor shifter similar to one used for a transmission or transaxle. The electric shift motor shown outside the transfer case housing in Figure 2 is sometimes installed inside the housing.

FIGURE 1

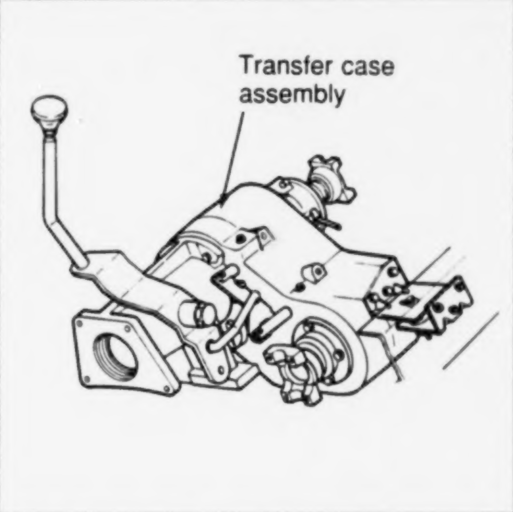

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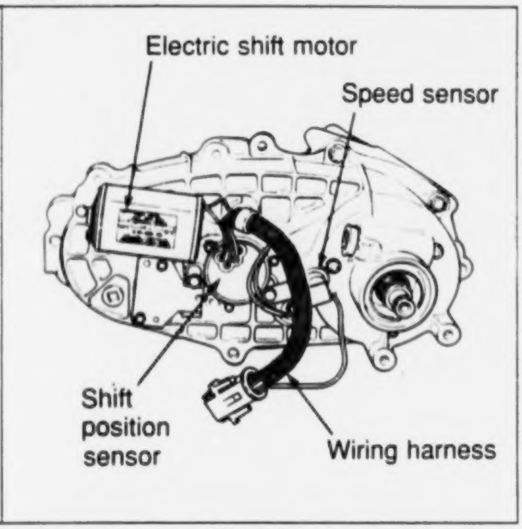
FIGURE 2



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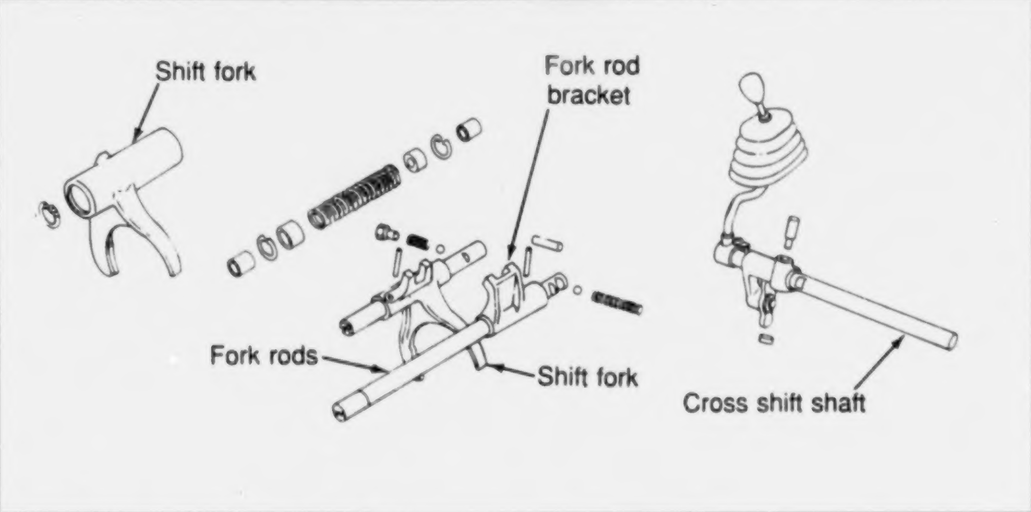
Regardless of the outside shifting mechanism, the shift components inside the transfer case usually consist of shift forks operating on rails. (Figure 3) In a part-time transfer case there is both a ***mode fork*** (which shifts the vehicle back and forth from four-wheel to two-wheel drive) and a ***range fork*** (which shifts the transfer case into HI, LO, or Neutral). A full-time transfer case has only a range fork. In electrically-shifted transfer cases, the shift forks are moved magnetically.

FIGURE 3



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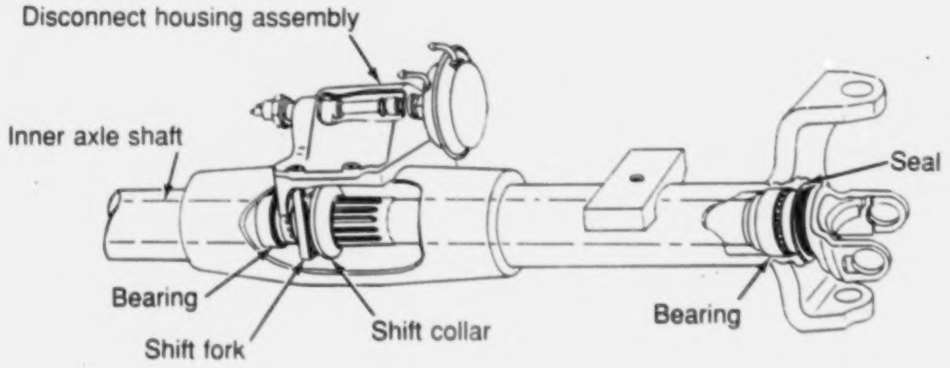
In addition to transfer case shifting components, the shift linkage may also activate a front axle disconnect mechanism and/or a rear wheel anti-locking brakes disconnect mechanism. Front axle disconnect mechanisms are either operated electrically or by a vacuum motor. A vacuum front axle disconnect mechanism is shown in Figure 4. (See Objective 6 for an illustration of an electrical front axle disconnect mechanism.) Electric and vacuum diagrams are available for units using these shifting methods. A rear wheel anti-locking brakes disconnect mechanism electrically disconnects the anti-locking brakes when the vehicle is shifted into four-wheel drive. The action of anti-locking brakes is not desirable during four-wheel drive operation.

Use the appropriate service manual for the correct adjustment procedures for all shifter components.

FIGURE 4


Disconnect housing assembly
Inner axle shaft
Seal
Bearing
Shift fork
Shift collar
Bearing

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EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 2

SERVICE FOUR-WHEEL DRIVE

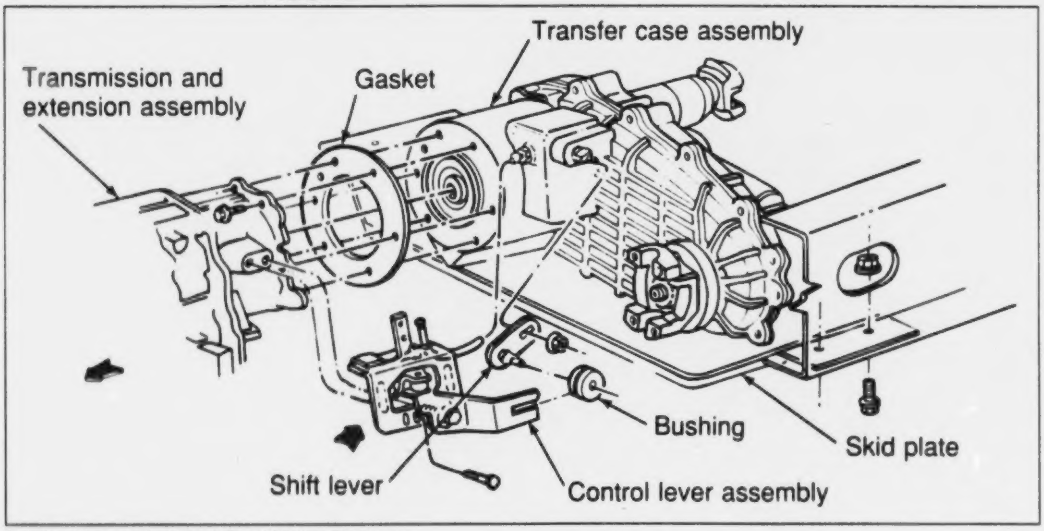
VI

OBJECTIVE 9B **Remove an independent four-wheel drive transfer case.**

INTRODUCTION

Although all transfer cases are not the same, removing one from a vehicle is very similar. (Figure 1) Remember to tag any wires or parts that you remove from the transfer case so they can be replaced easily.

FIGURE 1


Transfer case assembly
Transmission and extension assembly
Gasket
Bushing
Skid plate
Shift lever
Control lever assembly

Used with permission of Ford Motor Company.

EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Hoist or jack stands
- Hoist stand
- Combination wrenches
- Drain pan
- Mechanic's wire
- Masking tape & pen
- Screwdrivers
- Transmission jack or other suitable support

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

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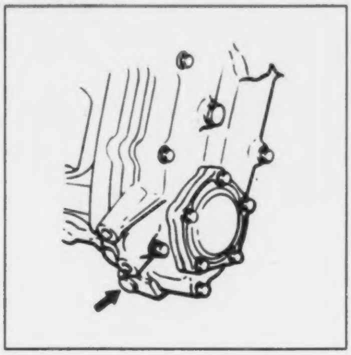
PROCEDURE

Remove an independent four-wheel drive transfer case

1. Raise the vehicle and support safely.

2. Locate the drain plug on the transfer case and drain the lubricant into a drain pan. (Figure 2)

FIGURE 2



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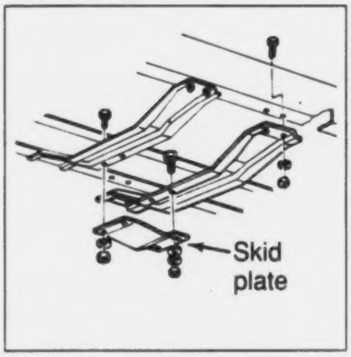
3. If there is a skid plate, remove it. (Figure 3)

   NOTE: A ***skid plate*** is a heavy metal plate installed under a component such as a transfer plate to protect it in rough terrain.

FIGURE 3



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4. Remove any exhaust system components that may be in the way.

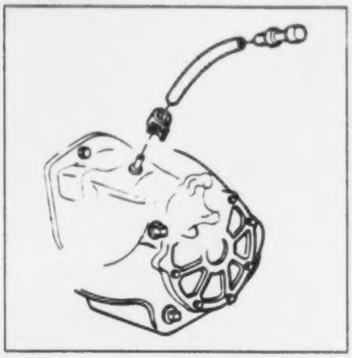
5. If there are electrical wires to the transfer case, remove them.

6. Remove the speedometer cable.

7. If there is a transfer case vent hose, disconnect it from the housing. (Figure 4)

   NOTE: On a four-wheel drive vehicle designed for use under rough conditions, ***vent hoses*** are used on all components which ordinarily have vents. The open end of the vent hose is installed at a higher position on the vehicle to avoid the water and dust that would enter through the vent if a vent hose was not used.

FIGURE 4



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8. Make matchmarks on the transfer case output shafts and both the front and rear drivelines as references for reinstallation.

9. Disconnect the front and rear drivelines and wire them out of the way.

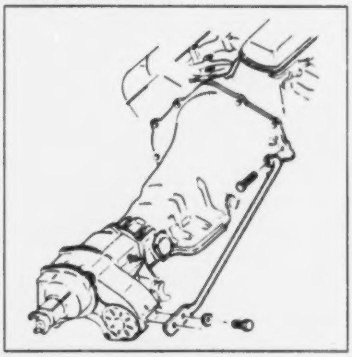
10. Disconnect the transfer case shift linkages from the case housing.

11. If the vehicle has an automatic transmission and has a strut rod between the transmission and the transfer case, remove the strut rod. (Figure 5)

12. Support and secure the transmission on a hoist stand.

13. Support and secure the transfer case on a transmission jack or other suitable support.

FIGURE 5



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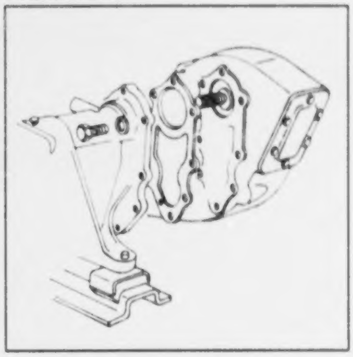
14. Remove the crossmember supports which hold the transfer case. (Figure 3 above)

15. Remove the bolts which hold the transfer case to the transmission. (Figure 6)

    NOTE: If the vehicle has a transmission adapter, remove the stud nuts or bolts which hold the transfer case to the transmission adapter.

16. Pull the transfer case rearward and down from the transmission.

FIGURE 6



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17. Place the transfer case on a workbench.

18. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

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JOB SHEET 3

SERVICE FOUR-WHEEL DRIVE

VI

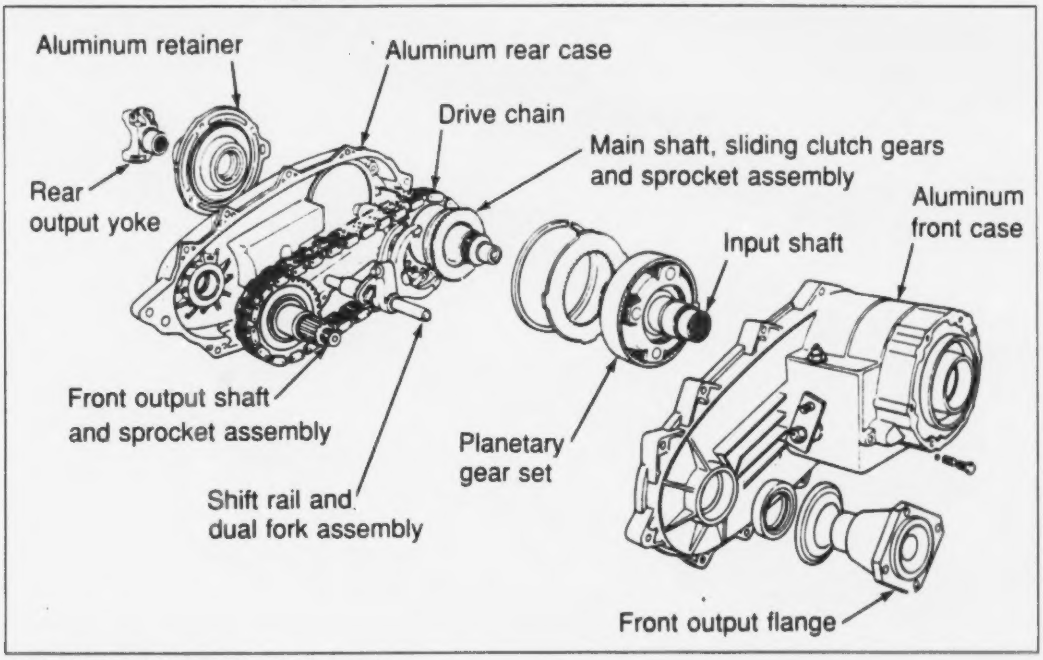
OBJECTIVE 9C

Remove, inspect, service, and replace transfer case components.

INTRODUCTION

The components in a transfer case will vary with the type and model of the case. Figure 1 and the illustrations for Objective 3 will give you an idea of some of the parts and components you may encounter.

FIGURE 1


Aluminum retainer
Aluminum rear case
Drive chain
Main shaft, sliding clutch gears and sprocket assembly
Rear output yoke
Aluminum front case
Input shaft
Front output shaft and sprocket assembly
Planetary gear set
Shift rail and dual fork assembly
Front output flange

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You must use an appropriate service manual in order to complete this job sheet, however many of the procedures you have already learned in this manual will prove useful. Here are some additional guidelines.

Guidelines

- Clean the outside of the case housing before disassembly to avoid getting dirt in the components it contains.
- Some manufacturers recommend that new nuts be used when the transfer case is reassembled.

- Special tools are sometimes required to remove and replace transfer case components.
- Shaft end play is checked as a part of service in most transfer cases. The appropriate service manual should be followed for specifications, location(s), and method of measurement.
- Some shims and snap rings may be a selective fit used to control shaft end play.
- Transfer case housings are usually made of aluminum. Follow the usual guidelines to avoid gouging or scratching the housing during disassembly and reassembly.
- Mark the range and mode forks with their rails so they can be rematched correctly upon reassembly.
- Be sure shift rail bores are free of lubricant, clean, and dry before replacing the shift rails. Lubricant in the bores will cause a hydraulic lock and the case halves will not fit together properly.
- Use petroleum jelly to install the needle bearings in the sprocket carrier. Make sure you install *all* the bearings.

EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Other equipment and material as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 4

SERVICE FOUR-WHEEL DRIVE

VI

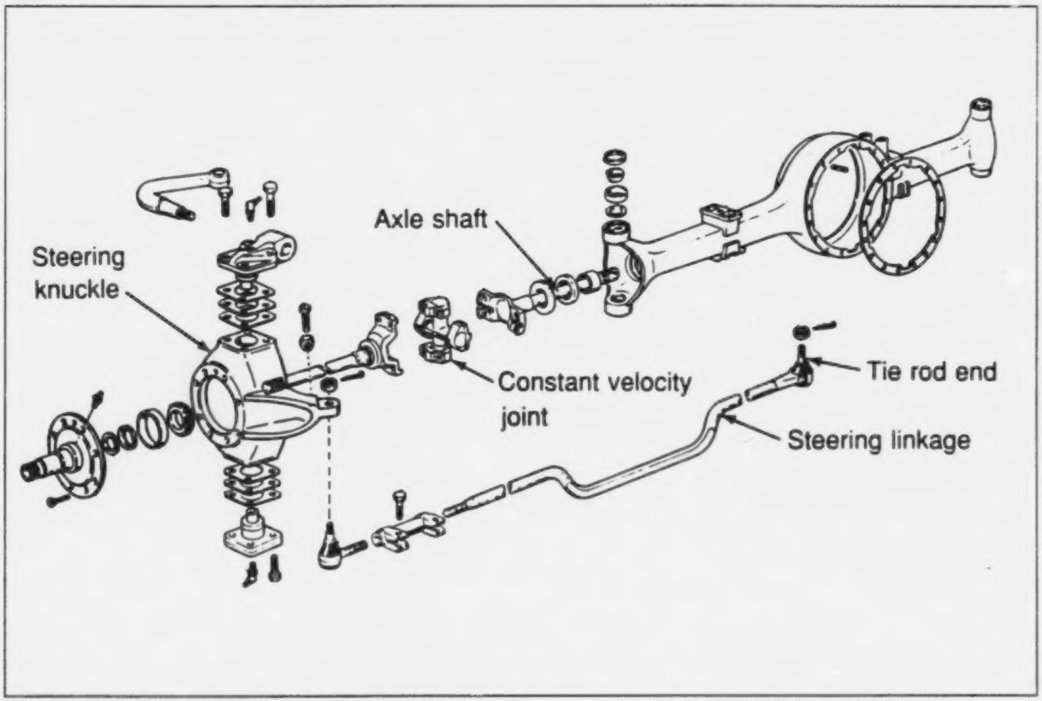
OBJECTIVE 9D

Remove and inspect front steering knuckles and drive axle assemblies.

INTRODUCTION

Because there are many designs used for front drive axles, steering knuckles, and suspension systems on four-wheel drive vehicles, the procedures given in individual vehicle service manuals must be followed precisely. The following two procedures are given as general guidelines for removing the steering knuckles and a solid front axle assembly (Figure 1) or an independent front axle assembly.

FIGURE 1



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Once the front axle assembly is removed, the front differential is serviced in the same way as a rear differential. (See Unit 2.)

EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Pry bar or slide hammer and attachment
- Lug wrench

- Hoist or jack stands
- Boot protectors
- Drain pan
- Mechanic's wire
- Combination wrenches
- Tie rod separator or puller
- Shop towels
- Axle puller if required
- Hub puller
- Approved cleaning solvent
- Bristle brush
- Crocus cloth or small file
- Small file

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Remove and inspect a solid front axle assembly

1. Set the vehicle in gear.
2. Remove the front hubcaps.
3. Use an appropriate wrench to loosen the lug nuts.
4. If the vehicle does not have locking hubs, loosen the axle nut.
5. Raise the vehicle on a hoist that supports the vehicle by the frame, not the tires.
6. Drain the differential lubricant into a drain pan.
7. Remove the lug nuts and wheels.
8. If the vehicle has locking hub assemblies, check the vehicle's service manual for the proper procedure and remove them.
9. Remove the brake calipers as recommended by the service manual.
10. Use mechanic's wire to hold the brake assemblies out of the way.
11. Use an appropriate wrench to remove the axle nut.

    NOTE: Manufacturers often specify a special heavy-duty tool for this purpose.

12. Remove the hub and rotor, if equipped.

13. Use an appropriate wrench to unbolt the spindle from the steering knuckle.

14. Pull the cotter pin and tie rod end nut to disconnect the steering linkage from the steering knuckle.

15. Use a tie rod separator (Figure 2) or tie rod puller (Figure 3) to pry the tie rod end from the steering knuckle.

FIGURE 2

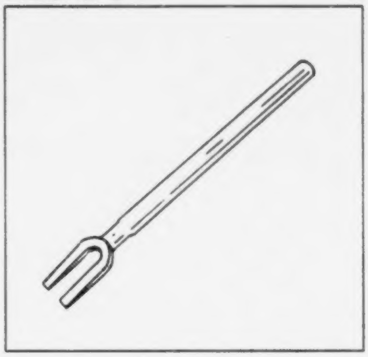
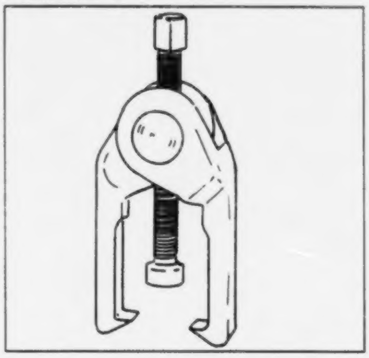


FIGURE 3



NOTE: Be sure not to damage the rubber boot over the tie rod.

16. Remove the steering linkage.

17. Follow the instructions in the service manual to remove the steering knuckle from the control arms.

18. If the axle is held in the differential by C-locks, open the differential housing and remove the C-locks.

19. If no C-locks are used, pull the axle from the differential.

    NOTE: The manufacturer may recommend that a special puller be used.

20. Place the axle on a workbench.

21. Use an approved cleaning solvent and a bristle brush to clean all parts.

22. Use clean compressed air to dry the parts.

23. Check the parts for damage and wear.

24. Inspect the universal joints using the procedures learned in Job Sheet 4, Unit 1.

25. Clean and inspect the bearings using the procedures in Supplement 5, Unit 2.

26. Check the service manual for the proper procedures to inspect and service the steering knuckle.

27. If C-locks are used, make sure they fit snugly and are not worn.

28. Bores in the steering knuckle should be smooth and free from wear.

29. Examine any splined areas for wear.

30. Use crocus cloth or a small file to remove any small burrs.

31. Replace worn or damaged parts.

32. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Remove and inspect an independent front axle assembly

1. Remove the front hubcaps.
2. Use an appropriate wrench to loosen the lug nuts.
3. If the vehicle does not have locking hubs, loosen the axle nut.
4. Raise the vehicle on a hoist that supports the vehicle by the frame, not the tires.
5. If recommended in the service manual, drain the differential lubricant into a drain pan.
6. Install boot protectors on the boots.
7. Remove the lug nuts and wheels.
8. If the vehicle has locking hub assemblies, remove them.
9. Remove the brake calipers as recommended by the service manual.

10. Use mechanic's wire to hold the brake assemblies out of the way.

11. Use an appropriate wrench to remove the axle nut.

    NOTE: Manufacturers often specify a special heavy-duty tool for this purpose.

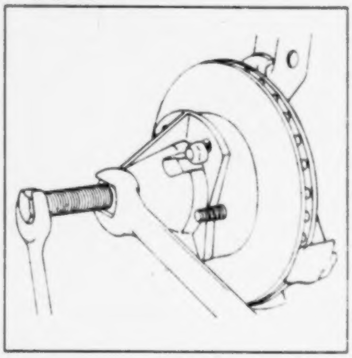
12. If there is no locking hub, use a special hub puller to press the wheel hub off the axle. (Figure 4)

13. If equipped, remove the nut and bolt holding the lower control arm's ball joint to the steering knuckle.

14. Pry the control arm ball joint away from the steering knuckle.

15. Remove the upper ball joint and the steering knuckle.

FIGURE 4



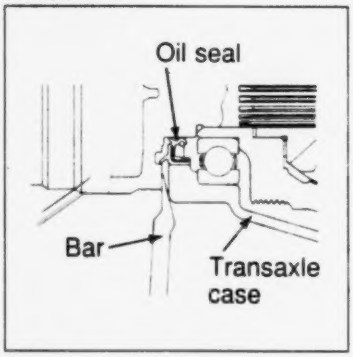
Used with permission of Chrysler Corporation.

16. If there is a flange holding the inner C-V joint to the differential, use the proper wrench to unbolt the flange and remove it.

17. If there is no flange, remove the axle with a slide hammer and attachment (See Job Sheet 2, Unit 5.) or insert a pry bar between the housing of the inner joint and the differential and pry the axle out of the differential housing. (Figure 5)

    NOTE: Do not insert the pry bar too deep or you will damage the oil seal. Be careful to support the inner C-V joint during this operation.

FIGURE 5



Used with permission of Chrysler Corporation.

18. Put a clean shop towel in the hole in the differential to keep out dust.
19. Place the axle on a workbench.
20. Use an approved cleaning solvent and a bristle brush to clean all parts.
21. Use clean compressed air to dry the parts.
22. Check the parts for damage and wear.
23. Use Job Sheet 4, Unit 5 to inspect the constant velocity joints.
24. Clean and inspect the bearings using the procedures in Supplement 5, Unit 2.
25. Check the service manual for the proper procedures to inspect and service the steering knuckle.
26. Bores in the steering knuckle should be smooth and free from wear.
27. Examine any splined areas for wear.
28. Use a crocus cloth or a small file to remove any small burrs.
29. Replace worn or damaged parts.
30. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 5 — SERVICE FOUR-WHEEL DRIVE — VI

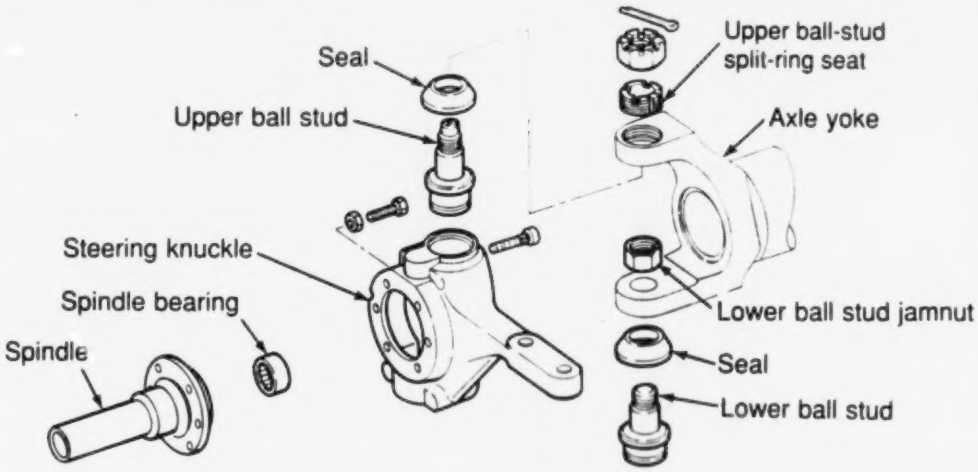
OBJECTIVE 9E

Inspect, service, and replace front wheel bearings and locking hubs.

INTRODUCTION

Many wheel bearings in front- or four-wheel drive vehicles are sealed and cannot be disassembled. If they are bad, they must be replaced. In some cases, the wheel bearing and the hub must be replaced as a unit. However, other front-wheel bearings can be disassembled. Unsealed bearings will fall apart when the hub is removed. Unsealed bearings must be cleaned and inspected very carefully. If the bearing is sound, it can be reinstalled and reused. The vehicle service manual will tell you what kind of front wheel bearings are used in the vehicle.

FIGURE 1


Seal
Upper ball stud
Upper ball-stud split-ring seat
Axle yoke
Steering knuckle
Spindle bearing
Spindle
Lower ball stud jamnut
Seal
Lower ball stud

Used with permission of Chrysler Corporation.

Many different models of locking hubs, both manual and automatic, are in use. The procedure given is a general procedure that can be used only for manual locking hubs. Procedures for removing, inspecting, and replacing automatic locking hubs are extremely variable and no general procedure would be useful. Procedures in the vehicle service manual must be followed exactly, whether the locking hub is manual or automatic

EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Supplement 5, Unit 2, ***Cleaning, Inspecting, and Lubricating Antifriction Bearings***

- Eye protection
- Approved cleaning solvent
- Low pressure air nozzle
- Lug wrench
- Hoist or jack stands
- Mechanic's wire
- Combination wrenches
- Special sockets/axle nut wrench as required
- Screwdriver
- Hub puller, if required
- Hammer and brass drift or
- Bearing puller
- Shop light
- Bearing driver
- Replacement wheel bearings, if required
- Bearing grease
- Replacement axle seals
- Replacement gaskets for locking hubs
- Approved lubricant for locking hubs

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect, service, and replace front-wheel bearings

1. Remove the front hubcaps.
2. Use a lug wrench to loosen the lug nuts.
3. If the vehicle does not have locking hubs, loosen the axle nut.
4. Raise the vehicle on a hoist that supports the vehicle by the frame, not the tires.
5. Remove the lug nuts and wheels.
6. If the vehicle has locking hub assemblies, check the vehicle's service manual for the proper procedure and remove them.
7. Remove the brake calipers as recommended by the service manual.
8. Use mechanic's wire to hold the brake assemblies out of the way.

9. Inspect the hub bearing by rotating the hub with your hands.

   NOTE: If the hub is rough, stiff, or noisy, the bearing will have to be replaced.

10. Remove the axle nut with an appropriate wrench.

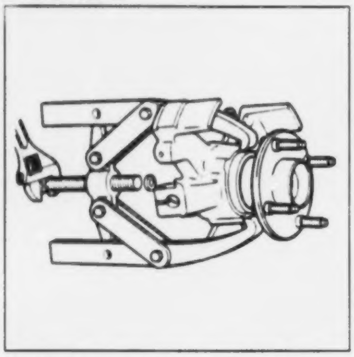
11. If necessary, use a hub puller to remove the hub from the axle. (Figure 2)

    NOTE: Some hubs are bolted to the axle and the bolts will have to be removed before the hub can be removed.

12. Remove the inner race(s) and bearing cage(s) from the hub.

13. Use a hammer and brass drift or a bearing puller to remove the outer bearing race(s) from the hub.

FIGURE 2



Used with permission of Ford Motor Company.

14. Use Supplement 5, Unit 2 as a guide to clean and inspect the wheel bearings.

15. Working under a shop light, use Supplements 5 or 8, Unit 2 to check the bearings for damage.

16. If the bearing is sound, use Supplement 5, Unit 2, to lubricate the bearing.

17. Use a bearing driver to reinstall the outer race(s) in the wheel hub.

18. Reinstall the bearing cage(s) and inner race(s).

19. Follow the instructions in Job Sheet 6 to reinstall the hub and front axle.

20. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Inspect, service, and replace manual locking hubs

1. Set the control knobs on the hubs to the FREE or UNLOCK position.

2. Shift the transfer case shift lever into the 2-wheel drive position.

3. Use an appropriate wrench to remove the cover bolts.
4. Remove the cover assembly.
5. Notice the position of the interior parts so you can reset them in the same position for reassembly.

   NOTE: It may be necessary to mark the position of these parts.

6. If there are outer shims, spacers, or snap rings, remove them.
7. Use an appropriate tool to remove the nuts or bolts which hold the hub assembly to the wheel hub.
8. Remove the hub assembly from the wheel hub.
9. Refer to the service manual for the proper procedures to inspect and service the locking hub parts.
10. Install a new gasket on the axle hub.
11. Replace the hub assembly.
12. Install the nuts or bolts holding the hub assembly to the wheel hub and torque to specifications.
13. Install any outer shims, spacers, or snap rings.
14. Measure the clearances of these components as directed in the service manual.
15. Lubricate the assembly as recommended in the service manual.
16. Set the interior parts in the FREE or UNLOCK position. (Refer to Step 5 above.)
17. Install a new gasket or seal.
18. Replace the cover assembly.
19. Replace the cover bolts and torque them to specifications.
20. Turn the control knob on the hub and check for proper operation.
21. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 6

SERVICE FOUR-WHEEL DRIVE

VI

OBJECTIVE 9F

Service and replace front steering knuckles and drive axle assemblies.

INTRODUCTION

Replacing the front drive axle assembly is largely a reversal of the removal process. The vehicle service manual should be followed closely—there are many variations on the basic types of front drive axle assemblies. The following procedures will give you some steps to follow.

EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Hoist or jack stands
- Lug wrench
- Combination wrenches
- Screwdriver
- Torque wrench
- Plastic mallet
- Hub puller
- New circlips for axle shaft
- New nut & bolt for lower control arm ball joint (if equipped)
- Appropriate differential lubricant

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

The vehicle should be on a hoist with the front axle assembly removed. (Job Sheet 4) The axle and its components should be cleaned, inspected, and lubricated. (Job Sheet 4) All work on the front differential should be completed, and the differential properly reassembled and installed. (Unit 2)

PROCEDURE

Service and replace a solid front axle assembly

1. Install new front differential seals according to the instructions in the vehicle service manual.

2. Lubricate the seal lips and the axle shaft splines with petroleum jelly.

3. Slide the axle shaft into the axle housing and align the splines on the shaft with the splines in the differential side gear.

4. Press in firmly to seat the axle shaft in the differential.
5. If C-locks are used to secure the axle inside the differential housing, install the C-locks.
6. Follow the instructions in the service manual to install the steering knuckle to the control arms.
7. Install the tie rod to the steering knuckle.
8. Tighten the tie rod nut and install the cotter pin.
9. Use an appropriate wrench to bolt the spindle shaft to the steering knuckle.
10. Torque the nuts to specifications.
11. Install the hub and rotor, if equipped.
12. Install the axle nut with an appropriate wrench.
13. Torque the nut to specifications.
14. Install the brake caliper as recommended by the service manual.
15. If the vehicle has locking hub assemblies, install them according to service manual instructions.
16. Install the wheel assembly and finger tighten the lug nuts.
17. Complete the above steps on the other axle.
18. Fill the front differential with the appropriate differential lubricant.
19. Use a lug wrench to snug the lug nuts.
20. Lower the vehicle from the hoist.
21. Torque the lug nuts to specifications.
22. Replace the front hubcaps.
23. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Service and replace an independent front axle assembly

1. The front drive axle boots and joints should be inspected and replaced if necessary. (Job Sheets 3 & 4, Unit 5)

2. Install new front differential seals according to instructions in the service manual.

3. Lubricate the seal lips and the stub shaft splines with petroleum jelly.

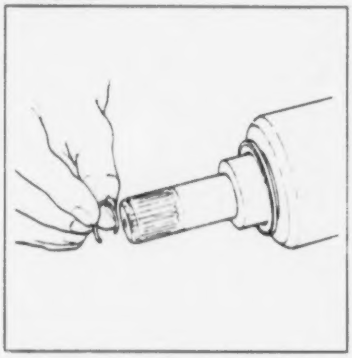
4. Install new circlips on the stub shafts. (Figure 1)

   CAUTION

   Be careful not to overexpand or twist the circlips.

5. Insert the end of the stub shaft into the differential housing and align the splines on the shaft with the splines in the differential side gear.

FIGURE 1



Used with permission of Ford Motor Company.

   CAUTION

   Support the C-V joint with your hand while you align the shaft splines.

6. Press firmly on the universal joint housing to seat the circlip in the groove in the differential side gear.

   NOTE: You may need to tap on the outer end of the drive axle with a plastic mallet to drive the shaft into the side gear.

7. If there is a flange which bolts the axle to the differential housing, bolt the flange to the housing and torque the bolts to specifications.

8. Connect the nut and bolt which hold the steering knuckle to the upper ball joint.

   NOTE: Use new nuts and bolts to connect the steering knuckle.

9. Install the nut and bolt holding the steering knuckle to the lower ball joint.

10. If there is no locking hub, install the hub on the axle with a special puller.

11. Install the axle nut with an appropriate wrench.

12. Torque the nut to specifications.

13. Install the brake caliper as recommended by the service manual.

14. If the vehicle has locking hub assemblies, install them according to service manual instructions.

15. Install the wheel assembly and finger tighten the lug nuts.

16. Complete the above steps on the other axle.

17. If necessary, fill the front differential with the appropriate differential lubricant.

18. Remove the boot protectors.

19. Lower the vehicle from the hoist.

20. Torque the lug nuts to specifications.

21. Replace the front hubcaps.

22. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 7

SERVICE FOUR-WHEEL DRIVE

VI

OBJECTIVE 9G

Replace an independent four-wheel drive transfer case and complete service.

INTRODUCTION

Replacing the transfer case is the reverse of the removal process. Care must be taken to correctly replace the many parts and components that may be attached. Be sure to clean and inspect these parts before replacing them—their operating condition will have an effect on the operation of the transfer case.

Check the appropriate service manual for the correct type and amount of transfer case lubricant. Most late model and domestic four-wheel drive vehicles use automatic transmission lubricant in the transfer case, while older models and some imports use a heavier weight lubricant. Transfer case fluid should be checked at least once a year or whenever the vehicle oil is changed and is usually filled to the bottom of the fill hole in the transfer case. Drive axle lubricant and the condition of vents should be checked at the same time. Different manufacturers may recommend additional servicing.

EQUIPMENT AND MATERIALS

- Four-wheel drive vehicle
- Appropriate service manual
- Eye protection
- Gasket(s) and/or liquid sealant as required
- Combination wrenches
- Screwdrivers
- Transmission jack or other suitable support
- Appropriate transfer case lubricant

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Replace an independent four-wheel drive transfer case and complete service

1. Clean and inspect the transfer case parts that will mate with the transmission case or be reconnected to it; lubricate parts as appropriate: transmission output shaft, transmission housing, transmission adapter, shift linkage, front and rear driveline slip joints, crossmember supports, skid plate, speedometer cable, transfer case vent hose, appropriate electrical connections.

2. Position the transfer case on a transmission jack.

3. If a gasket or liquid sealant is used between the transmission and/or the transmission adapter, install it as directed.

4. Pull the transfer case up and toward the transmission.

5. Bolt the transfer case to the transmission or transmission adapter, torquing the nuts to specifications.

6. Install the crossmember supports holding the transfer case to the vehicle frame; torque bolts to specifications.

7. Remove the transmission jack.

8. Remove the hoist stand from under the transmission.

9. If the vehicle has an automatic transmission, reconnect the strut rod between the transmission and the transfer case.

10. Reconnect the shift linkage.

11. Reinstall the front and rear drivelines to the transfer case.

    NOTE: Make sure matchmarks are mated to avoid driveline imbalance.

12. Install the transfer case vent hose, making sure there are no kinks in the hose.

13. Reinstall the speedometer cable.

14. Reconnect any electrical wires to the transfer case.

15. Replace any exhaust system components that may have been moved out of the way.

16. If a skid plate is used, reinstall it.

17. Refill the transfer case with the proper lubricant.

18. Check the transfer case housing for leaks.

19. Lower the vehicle

20. Test components as recommended by the manufacturer.

21. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 1

Inspect, adjust, and repair transfer case shifting components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle correctly.	_____	_____
3. Removed, inspected, and replaced shift linkage parts according to steps outlined in the appropriate service manual.	_____	_____
4. Adjusted and lubricated the shift linkage parts using recommended service manual procedures.	_____	_____
5. Tested the shift linkage adjustment correctly.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Remove an independent four-wheel drive transfer case.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Drained the transfer case and removed the skid plate (if present) and any obstructive exhaust system components correctly.	_____	_____
3. Disconnected the speedometer cable, vent hose(s), and any electrical wires.	_____	_____
4. Marked and removed the front and rear drivelines.	_____	_____
5. Disconnected the transfer case shift linkages.	_____	_____
6. Supported the transmission and the transfer case correctly.	_____	_____
7. Removed crossmember supports and transfer case to transmission bolts.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 3

Remove, inspect, service, and replace transfer case components.

STUDENT'S NAME ________________ DATE ____________

EVALUATOR'S NAME ______________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Cleaned the outside of the transfer case before disassembly.	_____	_____
3. Used the procedures in the appropriate service manual as a guide for completing all steps.	_____	_____
4. Followed job sheet Guidelines in removing, inspecting, servicing, and replacing transfer case components.	_____	_____
5. Checked and adjusted shaft end play and made any other measurements as recommended by the manufacturer.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Remove and inspect front steering knuckles and drive axle assemblies.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Followed the procedures in the appropriate service manual as a guide for completing all steps.	_____	_____
3. Removed the wheel, brake assembly, and hub correctly.	_____	_____
4. Disconnected the steering knuckle from the steering and suspension systems following procedures outlined in the service manual.	_____	_____
5. Removed the axle from the front differential correctly.	_____	_____
6. Cleaned and inspected all parts following outlined procedures.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 5

Inspect, service, and replace front-wheel bearings and locking hubs.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the procedures in the appropriate service manual as a guide for completing all steps.	_____	_____
3. Removed the manual locking hubs following outlined procedures.	_____	_____
4. Cleaned and inspected the locking hubs following the manufacturer's guidelines.	_____	_____
5. Lubricated and replaced the locking hubs according to outlined procedures.	_____	_____
6. Removed the front-wheel bearings correctly.	_____	_____
7. Cleaned and inspected the bearings following the procedures given.	_____	_____
8. Lubricated and replaced the front-wheel bearings following outlined procedures.	_____	_____

	YES	NO
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Service and replace front steering knuckles and drive axle assemblies.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the procedures in the appropriate service manual as a guide for completing all steps.	_____	_____
3. Installed axles in the front differential following suggested guidelines.	_____	_____
4. Replaced the steering knuckling according to service manual procedures.	_____	_____
5. Reconnected the steering and suspension systems to the steering knuckle correctly.	_____	_____
6. Replaced the hub, brake, and wheel assemblies.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE FOUR-WHEEL DRIVE

JOB SHEET 7

Replace an independent four-wheel drive transfer case and complete service.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used the procedures in the appropriate service manual as a guide for completing all steps.	_____	_____
3. Replaced transfer case to transmission bolts and crossmember supports.	_____	_____
4. Supported the transmission and the transfer case correctly during reassembly.	_____	_____
5. Reconnected the transfer case shift linkage following procedures outlined in the vehicle service manual.	_____	_____
6. Replaced the front and rear drivelines correctly.	_____	_____
7. Reconnected the speedometer cable, vent hose(s), and any electrical wires.	_____	_____
8. Replaced the skid plate and exhaust system components as required.	_____	_____
9. Filled the transfer case with the appropriate lubricant.	_____	_____

	YES	NO
10. Observed safety rules and precautions.	____	____
11. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS ____

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE FOUR-WHEEL DRIVE

VI

NAME ______________________ SCORE ______

OBJECTIVE 1

Choose the correct definitions for terms associated with four-wheel drive vehicles by selecting the correct definition from four choices. Select the best definition for each term.

______1. **all-wheel drive vehicle**

A. A type of part-time four-wheel drive vehicle which has a transfer case built into its transaxle
B. A type of full-time four-wheel drive vehicle which uses a viscous coupling rather than a transfer case
C. A type of full-time four-wheel drive vehicle which has a transfer case built into its transmission
D. A type of full-time four-wheel drive vehicle which has a transfer case built into its transaxle

______2. **automatic locking hub**

A. Will connect or disconnect the drive wheel and the drive axle automatically, without its hub control knob being set by hand
B. Will connect or disconnect the drive axle from the front differential automatically without its hub control knob being set by hand
C. Will connect or disconnect the hub from the wheel and drive axle
D. Will connect or disconnect the drive wheel to the drive axle only if its hub control knob is set by hand

______3. **four-wheel drive vehicle**

A. A type of vehicle in which all four wheels can be manually or automatically connected or disconnected to the drive axles
B. A type of all-wheel drive vehicle which has a transfer case built into its transaxle
C. A type of vehicle designed to allow all four wheels to drive the vehicle at the same time
D. A type of vehicle designed to allow all four wheels to turn at the same time

______4. **front axle disconnect mechanism**

A. A special assembly used with a front differential which can be set manually to lock up the differential action and force an equal supply of power to both axles
B. A special assembly built into the front axle which allows one of the front drive axles to be automatically connected and disconnected from the front differential
C. A special assembly built into the front axle which allows both of the front drive axles to be automatically connected and disconnected from the front differential
D. A special assembly which changes a full-time transfer case into a part-time transfer case

______5. **full-time transfer case**

A. Transfers torque from the transmission to both the front and the rear drive axles at all times
B. A type of transfer case which uses direct gearing to transfer torque to either the front or the rear drive axle
C. Transfers torque from the transmission to *either* the rear drive axles *or* to both the front and rear drive axles
D. An independent unit which receives torque from the transaxle and transfers it to the rear drive axles

______6. **independent front axle assembly**

A. Has a universal joint only at the outboard end of each axle and is contained in an axle housing
B. Has universal joints at both ends of the axle and is contained in an axle housing
C. Has constant velocity joints at both ends of each half shaft and is contained in an axle housing
D. Typically has constant velocity joints at both ends of each half shaft and is not contained in an axle housing

______7. **lock-out mechanism**

A. A special assembly built into the front axle which allows one of the front drive axles to be automatically connected and disconnected to the front differential
B. A special assembly used with a transfer case differential which can be set manually to lock up the differential action and force an equal supply of power to both axles
C. A special assembly used with a front differential which can be set manually to lock up the differential action and force an equal supply of power to both axles
D. A unit that transfers torque between two drivetrain components using a fluid (such as silicone) which can force an equal supply of power to both axles

______8. **locking hub**

A. A type of hub which can be locked to brake a four-wheel drive vehicle when it is operating on steep grades
B. A type of hub used on front or rear drive wheels which allows the wheel to be connected or disconnected to the drive axle
C. A type of hub used on front drive wheels which allows the wheel to be connected or disconnected to the drive axle.
D. A type of hub used on front drive wheels which allows the hub to be disconnected from the wheel and the drive axle

______9. **manual locking hub**

A. Will connect or disconnect the drive wheel and the drive axle automatically, without its hub control knob being set by hand
B. Will connect or disconnect the drive axle from the front differential automatically without its hub control knob being set by hand
C. Will connect or disconnect the hub from the wheel and drive axle
D. Will connect or disconnect the drive wheel to the drive axle only if its hub control knob is set by hand

_____10. **part-time transfer case**

A. Transfers torque from the transmission to both the front and the rear drive axles at all times
B. A type of transfer case which uses a direct gearing to transfer torque to the front or the rear drive axle at all times
C. Transfers torque from the transmission to *either* the rear drive axles *or* to both the front and rear drive axles
D. An independent unit which receives torque from the transaxle and transfers it to the rear drive axles

_____11. **solid front axle assembly**

A. Has a universal joint only at the outboard end of each axle and is contained in an axle housing
B. Has universal joints at both ends of the axle and is contained in an axle housing
C. Has constant velocity joints at both ends of each half shaft and is contained in an axle housing
D. Has constant velocity joints at both ends of each half shaft and is not contained in an axle housing

_____12. **steering knuckle**

A. A steering system component which connects the steering linkage to the front drive axles and sometimes the front suspension
B. A steering system connection found between the two tie rods which coordinates drive wheel action during steering
C. A drivetrain component which accepts torque from the drive axle and transfers it to the steering system
D. A steering system component which connects the front or rear suspension with the appropriate drive axle

_____13. **transfer case**

A. A drivetrain component that transfers torque between two other drivetrain components using a fluid (such as silicone) which allows for a degree of slippage between the components
B. A drivetrain component in a four-wheel drive vehicle which accepts torque from the transmission and transmits it to the front and rear drive axles
C. A drivetrain component in a four-wheel drive vehicle which accepts torque from the transmission and transmits it to the rear drive axles only
D. A drivetrain component which transfers torque from a rear engine to a front wheel drivetrain

_____14. **viscous coupling**

A. A drivetrain component on all-wheel drive vehicles which acts in place of a transfer case
B. A unit in a four-wheel drive vehicle which accepts torque directly from the transmission and transfers it to either the front or the rear drive axles
C. A unit that transfers torque between two drivetrain components using a fluid (such as silicone) which allows for a degree of slippage between the components
D. A unit that transfers torque between the transmission and the transfer case

OBJECTIVE 2 **List the advantages and disadvantages of using four-wheel drive.**

ADVANTAGES:

1. ____________________________________
____

2. ____________________________________
____

3. ____________________________________
____

DISADVANTAGES:

1. ____________________________________
____

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2. ______________________________

____

3. ______________________________

____

4. ______________________________

____

5. ______________________________

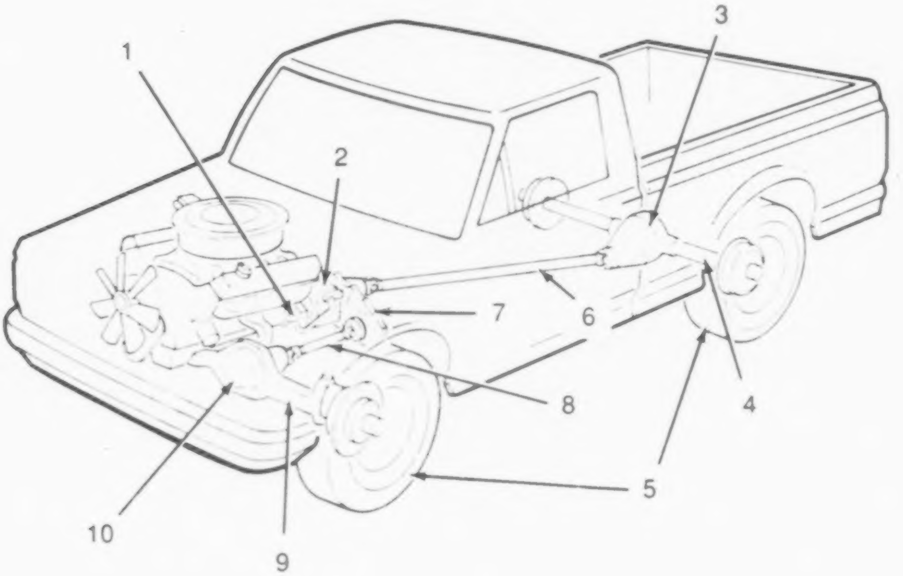
____

6. ______________________________

____

OBJECTIVE 3

Match the names of the components of a four-wheel drivetrain to an illustration. Select the name of the correct drivetrain component for each blank.



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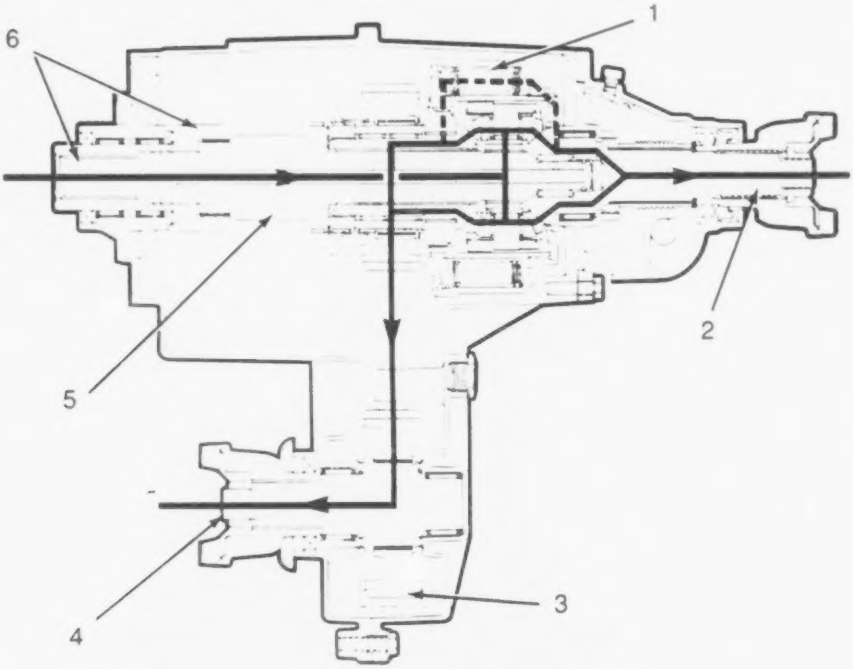
______1.
______2.
______3.
______4.
______5.
______6.
______7.
______8.
______9.
_____10.

A. Clutch
B. Drive wheels
C. Front differential
D. Front drive axle
E. Front driveline
F. Rear differential
G. Rear drive axle
H. Rear driveline
I. Transfer case
J. Transmission

OBJECTIVE 4 **Label the major types of transfer cases and match the names of their parts to illustrations.** Write the type of transfer case in the large blank and choose the name of the correct part for each blank.



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A. Type of transfer case: ______________________________

______1. A. Drive sprocket

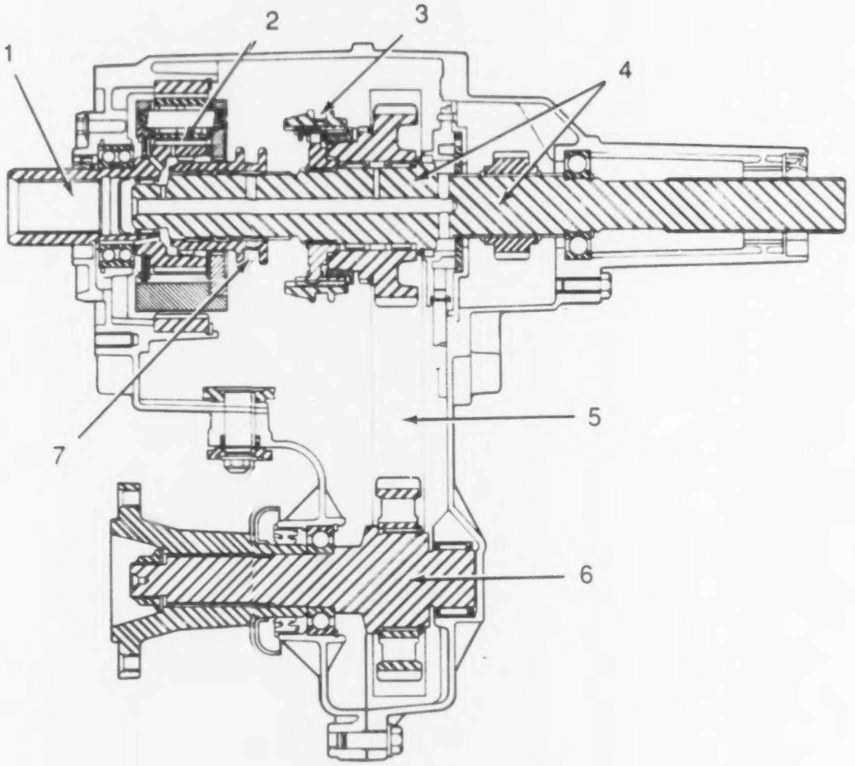
______2. B. Front output shaft

______3. C. Input shaft

______4. D. Mainshaft

______5. E. Rear output shaft

______6. F. Viscous coupling



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B. Type of transfer case: ______________________________

_______1. A. Drive chain

_______2. B. Front output shaft

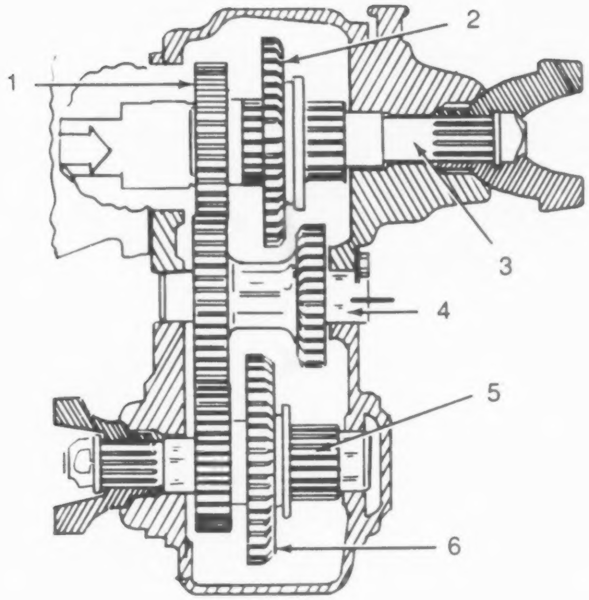
_______3. C. Input shaft

_______4. D. Mode shift assembly

_______5. E. Planetary gear set

_______6. F. Range shift assembly

_______7. G. Rear output shaft



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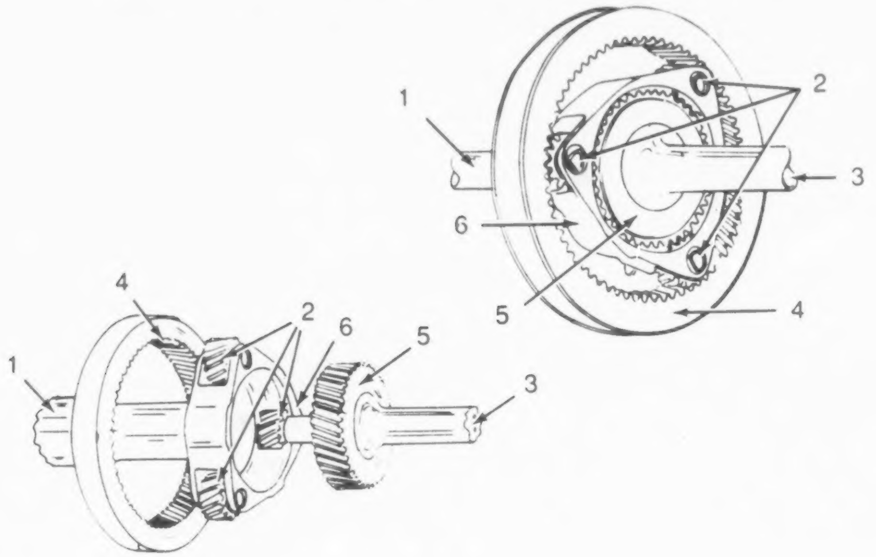
C. Type of transfer case: ______________________

_______1.	A.	Countershaft
_______2.	B.	Front output shaft
_______3.	C.	Front output shaft sliding gear
_______4.	D.	Input shaft gear
_______5.	E.	Rear output shaft
_______6.	F.	Rear output shaft sliding gear

OBJECTIVE 5 **Match the names of the parts of a planetary gear assembly to illustrations.** Select the correct name for the part indicated.



______1. A. Carrier shaft

______2. B. Internal ring gear

______3. C. Planet-pinion carrier

______4. D. Planet-pinion gears

______5. E. Sun gear

______6. F. Sun gear shaft

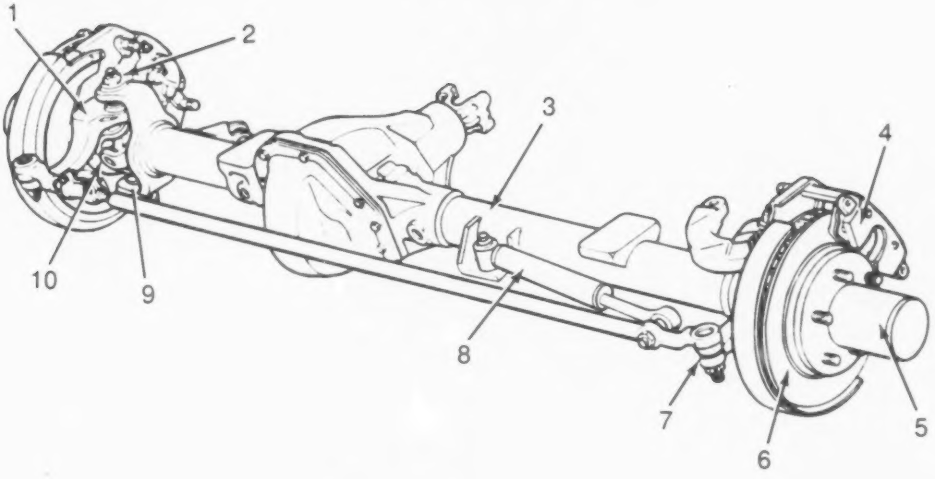
OBJECTIVE 6 **List three ways the front drive axles can be disconnected in a four-wheel drive vehicle.**

1. ______________________________

2. ______________________________

3. ______________________________

OBJECTIVE 7 **Label the major types and parts of front drive axles used on four-wheel drive vehicles on illustrations.** Write the type of front drive axle in the large blank, write the name of the part indicated in the space following the corresponding letter.



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A. Type of front drive axle assembly: ______________________________

____

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

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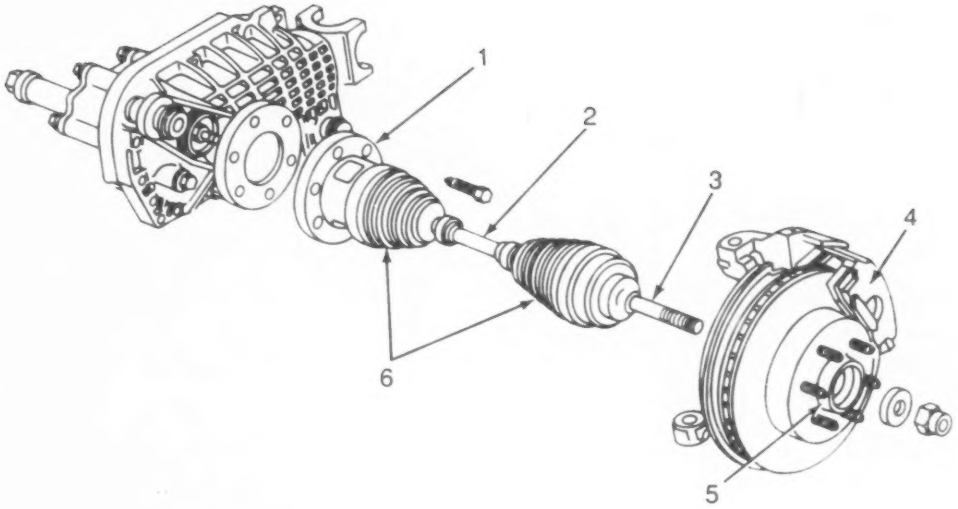

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B. Type of front drive axle assembly: ____________________

____

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

1050

WRITTEN TEST ANSWERS

SERVICE FOUR-WHEEL DRIVE

VI

OBJECTIVE 1

1. D
2. A
3. C
4. B
5. A
6. D
7. B
8. C
9. D
10. C
11. A
12. A
13. B
14. C

OBJECTIVE 2

The answers should include all of the following:

ADVANTAGES:

- Better traction for driving in off-road situations, in sand, mud, deep snow, and on ice
- Increased power availability
- Can be towed safely without damaging the transmission

DISADVANTAGES:

- Greater vehicle weight
- Less horsepower to the wheels
- Increased drivetrain friction
- Decreased fuel economy
- Greater tire wear
- Higher maintenance costs

OBJECTIVE 3

1. A
2. J
3. F
4. G
5. B
6. H
7. I
8. E
9. D
10. C

OBJECTIVE 4

A. Full-time transfer case

1. F
2. E
3. A
4. B
5. D
6. C

B. Part-time chain-driven transfer case

1. C
2. E
3. D
4. G
5. A
6. B
7. F

C. Part-time gear-driven transfer case

1. D
2. F
3. E
4. A
5. B
6. C

OBJECTIVE 5

1. A
2. D
3. F
4. B
5. E
6. C

OBJECTIVE 6

The answer should include all of the following:

- Manual locking hubs
- Automatic locking hubs
- Front axle disconnect mechanism

OBJECTIVE 7

A. Solid front axle assembly

1. Steering knuckle
2. Upper ball joint
3. Axle housing
4. Brake caliper
5. Hub
6. Brake rotor
7. Tie rod
8. Steering stabilizer
9. Lower ball joint
10. Constant velocity joint

B. Independent front axle assembly

1. Flange
2. Half shaft
3. Spindle shaft
4. Brake caliper
5. Hub assembly
6. Constant velocity joints

MANUAL DRIVETRAIN/AXLES SPECIALIST

CI

UNITS OF INSTRUCTION STATE/LOCAL CODES*	READING SKILLS																																	WRIT		
	Reading Comprehension									Research and Reference								Functional Reading						Language		Composition								Res		
	Gain factual information	Distinguish fact, opinion and inference	Recognize stereotyping and bias	Recognize propaganda	Analyze cause and effect	Draw conclusions	Make generalizations	React to written material	Apply word analysis techniques	Select useful resources	Locate resources	Find materials in library	Use standard references	Use in-book reference tools	Use audiovisual media	Use computer data base	Use magazines and newspapers	Interpret forms and records	Follow written instructions	Interpret graphics and symbols	Use content area vocabulary	Interpret abbreviations/acronyms	Read aloud	Use standard grammar and correct spelling, punctuation, and capitalization	State ideas clearly	Use complete sentences	Develop preliminary outline	Use topic sentence	Use introductory/closing paragraphs	Compose reports	Compose essays	Proofread and edit	Construct graphics and symbols	Take notes	Use notecards	Create bibliography
Service Drivelines						●							●	●					●	●	●															
Service Differentials and Rear Drive Axles	●					●							●	●					●	●	●															
Service Clutches													●	●					●	●	●															
Service Manual Transmissions													●	●					●	●	●															
Service Manual Tranaxles and Front Drive Axles													●	●					●	●	●															
Service Four-Wheel Drive						●							●	●					●	●	●															

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MC BASIC SKILLS DOCUMENTATIO

'NG SKILLS

MATH SKILLS

ch		Functional Writing							Operation and Calculation														Math Application											Data Analysis and Display													
Use footnotes	Outline material	Complete forms and records	Write instructions	Write letters	Write job applications	Write resumes	Use word processing	Use computer graphics	Round off numbers	Estimate answers	Use scientific notations	Use exponential notations	Calculate with whole numbers	Calculate with fractions	Calculate with decimals	Convert whole numbers to fractions	Convert whole numbers to decimals	Solve numerical expressions	Solve formulas and equations	Obtain squares and square roots	Convert units of measure	Perform metric calculations	Solve word problems	Select/apply mathematical formula	Select/apply mathematical procedure	Use English and metric measures	Solve time/rate/distance problems	Solve ratio/proportion problems	Solve percent problems	Apply techniques of scaling	Apply algebra principles	Apply geometry principles	Apply trigonometry principles	Interpret charts and tables	Interpret graphs (type)	Collect /record data	Apply sampling techniques	Apply principles of probability	Construct charts and tables	Construct graphs	Calculate statistics	Interpret statistics	Interpret blueprints/plans	Make measurements	Perform banking transactions	Make change	Solve practical problems
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N MATRIX

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Stillwater, Oklahoma 74074-4364

SCIENCE SKILLS

92 006805

Functional Math										General Science									Life Science							Physical Science					Earth Science							
Calculate gross earnings	Solve income/expense problems	Prepare a budget	Calculate interest	Solve interest problems	Calculate sales tax	Determine income tax	Use calculator for computation	Use computer for computation	Use computer spreadsheets	Apply computing skills	Apply scientific method of inquiry	Conduct experiments	Investigate science ethics	Investigate science history	Investigate/apply economics in technology	Use scientific instruments	Investigate/apply technology	Collect specimens	Identify/classify living organisms	Investigate biological history of the earth	Investigate food chains, webs, pyramids	Investigate/apply principles of human development	Investigate/apply principles of genetics/heredity	Investigate/apply principles of anatomy/physiology	Investigate health issues	Analyze/classify matter	Investigate forms/changes of matter	Investigate forms/changes of energy	Investigate/apply chemical properties	Investigate/apply physical laws	Investigate physical characteristics of the earth	Investigate geological history of the earth	Investigate physical forces acting on the earth	Solve problems of longitude, latitude, and time zones	Investigate conservation of physical resources	Investigate conservation of living resources	Investigate issues of environmental impact	Apply science principles to environmental issues
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UNITS OF INSTRUCTION STATE/LOCAL CODES*	**ORAL COMMUNICATIONS SKILLS**																							**INTERPERSON**																
	Oral Presentation									Listening				Interactive Communication										General Relations																
	Make informative presentations	Make persuasive presentations	Present personal opinion/viewpoint	Use good speaking techniques	Select/use words effectively	Use effective body language	Present appropriate appearance	Integrate audio and/or visual materials in oral presentations	Adapt presentation to specific audience	Apply active listening skills	Distinguish fact, opinion, and interference	Draw conclusions/make generalizations	Analyze/identify point of view	Give/follow oral directions	Apply questioning techniques	Conduct/receive interviews	Analyze/apply nonverbal communication	Work effectively in a group	Communicate with clients/customers/patients	Communicate with co-workers	Communicate with supervisors	Communicate with professional colleagues/associates	Apply telephone etiquette	Investigate/apply communication process models	Analyze/apply nonverbal communication	Investigate/apply cross-cultural communication	Interact with co-workers	Interact with supervisors	Interact with clients/customers/patients	Interact with professional colleagues/associates	Interact with family/friends	Participate in group activities	Participate in industrial relations/functions	Identify personal values/attitudes	Apply information to life experiences	Identify values/attitudes	Identify needs/drives	Select/apply appropriate behavior	Investigate/identify personal styles	Investigate/identify group/
Service Drivelines														●													●													
Service Differentials and Rear Drive Axles														●													●													
Service Clutches																											●													
Service Manual Transmissions																																								
Service Manual Tranaxles and Front Drive Axles																																								
Service Four-Wheel Drive																																								

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Developer of the Natic

AL OR RELATING SKILLS

Teamwork Cooperation											Leadership						
corporate climate	Give/receive feedback	Identify hidden purposes	Investigate/apply group dynamics	Control undesirable/ inappropriate behavior	Resolve conflicts	Clarify goals/objectives	Devise "win/win" situations	Build consensus	Generate ideas	Present point of view	Analyze/apply leadership styles	Analyze/apply management styles	Obtain confidence of others	Develop esteem in self/others	Persuade others	Analyze/apply motivation techniques	Provide positive coaching

CREATIVE THINKING/ PROBLEM SOLVING SKILLS

Cognitive Activities																		
Collect/record information	Identify critical elements/issues	Define a problem	Identify underlying causes	Apply a problem-solving model	Analyze/synthesize information	Identify/analyze underlying assumptions	Draw conclusions	Predict results/outcomes	Identify/evaluate consequences	Identify/develop alternatives	Evaluate alternatives	Select an alternative	Devise a solution	Create a finished product	Apply intuitive/creative thinking processes	Transfer knowledge/training to new situations	Apply new technology	Develop an action plan	Evaluate results/outcomes
							●									●			
							●									●			●
							●									●			●
							●									●			●
																●			
							●									●			

EMP

Job Search Selection							
Analyze personal occupational aptitudes/preferences	Investigate employment prospects of a career field/occupation	Investigate training requirements for a career field/occupation	Investigate benefits of a career field/occupation	Compare/evaluate career options	Develop personal career path	Locate appropriate jobs	Analyze duties/requirements/benefits of specific job

OYABILITY SKILLS

Job Acquisition [illegible]

Master specific job task/procedure	Fill in job-related applications	Write letter of application	Write personal resume	Interview for a job	Apply business etiquette	Practice good work habits/attitudes	Develop good personal presentation	Develop self-confidence/esteem	Develop effective leadership	Deal effectively with supervisors	Deal effectively with co-workers	Deal effectively with professional colleagues/associates	Deal effectively with customers/clients
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Information Analysis

Collect/record data	Interpret graphical information	Construct graphical information	Interpret maps/globes	Interpret statistical information	Analyze/interpret demographic information

SOCIAL STUDIES SKILLS

Social Studies Applications

Investigate/apply U.S. history	Investigate/apply world history	Investigate/apply U.S. geography	Investigate/apply world geography	Investigate/apply principles of government/politics	Investigate/apply principles of economics	Investigate/apply principles of ethics	Investigate/apply principles of psychology	Investigate/apply principles of sociology	Investigate/apply cross-cultural studies

Functional Social Studies

Practice responsible personal economics	Prepare a personal budget	Use credit responsibly	Practice good work ethics	Participate in industrial relations	Interact with people of different races/cultures	Investigate/participate in government	Investigate/apply American legal practices	Select/use sources of information on current events	Analyze current events	Analyze consumer issues	Analyze social issues	Analyze conservation/ecology issues	Analyze social impact of science/technology	Analyze economic impact of science/technology